BIOLOGY

BOOK IV

(Experimental Edition)

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BIOLOGY

BOOK IV

(Experimental Edition)

A TEXT BOOK FOR SECONDARY AND HIGH SCHOOL CLASSES

Prepared by

NCERT STUDY GROUP IN BIOLOGY

NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

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CONTENTS

CHAPTER IV

WEB OF LIFE

CHAPTER V

CYCLES OF MATTER

CHAPTER VI

CONSERVATION OF NATURE AND NATURAL RESOURCES

PREFACE

In Presenting Biology Books IV—VI, designed for use in the High School classes in our country, we have extended the biological concepts already enunciated in the earlier series I—III published in 1968 for use in our middle schools. In formulating the curriculum for high schools, we have been guided primarily by the basic principles that there is an urgent and pressing need to update the scientific content in the teaching of the dynamic aspects of biology.

In designing a higher level Biology Course we realize that to do full justice to it we need much more laboratory equipment than what is available now. Therefore, perforce, this curriculum had to be designed to suit our needs and at the same time to enhance the present standards.

To pass on from the classical descriptive approach in the teaching and learning of biology to an experimentally oriented course is not a very easy task. Still, one cannot avoid this transformation when biology as it is today is as much a specific and precise science as any other. We have sought to approach the High School Student through the environment, leading him on to the dynamic aspects of the functional mechanisms of organisms and culminating in a study of heredity, behaviour and the social implications of Biology. We hope that this series will be the harbinger of greater changes in Biology teaching at the higher levels of education.

The teachers and schools in the rural areas have been our great concern and we look forward to a meaningful and purposeful utilization of our material. From both the urban and rural areas, we expect to receive a well-guided appraisal of the present texts and guides. A questionnaire is appended to the books which we hope will be used to give us valuable feed back to enable us to revise our material.

It is needless to say that our group derived much inspiration from the B.S.C.S. and Nuffield materials.

We, in the Biology Study Group, are conscious of the immense support we have received from Professor D. S. Kothari, Chairman, University Grants Commission, and Dr. L. S. Chandrakant, Joint Educational Adviser, Ministry of Education, Government of India, on all occasions. To Professor S. V. C. Aiya, Director, NCERT, Sarva Shris Rajendra Prasad, G. S. Baderia and S. Doraiswami of the NCERT, who have always willingly given us of their time and talent in the fulfilment of our task, we offer our best thanks.

We sincerely feel that the fullest advantage would be derived if the material presented here is made use of either in English or as translations into regional languages on a national scale. It is only then that our efforts would have been fully put to test.

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T. S. SADASIVAN

CHAPTER I

LIFE IN WATER

Introduction

You are aware that water occupies a key position in driving life processes in all living systems. Ponds, rivers, sea and even damp soil, provide a slimy envelope of water for a wide variety of living organisms. Water, as you can well visualize, is the most abundant substance found in all living cells and tissues. Nearly 70% of the surface of the earth is covered with water, mostly the seas. If we take into account ponds, lakes and rivers, the quantity of water on the surface of the earth is amazing !

It is, therefore, not surprising that water supports a larger variety and number of living beings than land. We may now study some aspects of life in water.

Water, as a medium of life

Water has to be taken into the bodies of organisms in some form or the other, because life is not possible without it. Since water is both essential and most abundant in living matter, it might be said that life is in a sense aquatic. Not only animals that live in water, but also terrestrial animals including man and terrestrial plants are inevitably and absolutely dependent on water. Most basic necessities of life are to be dissolved in water before they can enter into the tissues of organisms. The real difference in the lives of aquatic and terrestrial organisms is that, the former are literally bathed in an envelope of water which can be taken in and held inside their bodies with minimum effort, whereas the latter have to make special efforts to get the much needed water. Furthermore, the terrestrial forms have to be equipped to retain

water in their tissues, and, indeed, they may have to travel for it or get it from their food or drink water as such. Plants may have to develop root systems for absorption, and protective covering on the lamina, or other special activities or structures that would help to minimize loss of water.

We can now assume that :

(a) Some parts of the aquatic environment may contain more essential energy substances than others and this may be the reason why some species find some parts of the environment more favourable than others ; and

(b) such favourable locations occur in different parts of the environment and cause uneven distribution of organisms.

Study of life in an aquarium

We may begin with a study of life in an aquarium established in your class room.

The organisms in the aquarium

You will notice that the aquarium tank in the class room contains a large variety of living things, both plants and animals. You will find that some animals in the tank are more active than others. By observing these organisms, it is possible to compile data about some organisms that live in water.

Tabulate your observations in the following form :

	POSITION IN AQUARIUM				
Name of species	*On surface of water*	*On the walls of the aquarium*	*Just below the surface of water*	*On the bottom of the tank*	*Any other position (plants and animals)*
1	2	3	4	5	6

From the data collected you will notice even within the limited space of an aquarium that

(a) organisms are not distributed evenly ;

(b) some organisms are more commonly seen in one part of an aquarium than in another.

It is well to realize that the environment in the aquarium shows various active organisms besides physical features (the water in the aquarium, its solutes, the mud and the stones that provide shelter for the organisms).

The environment for the organisms in the aquarium tank is water and other objects (living and non-living). The organisms in the aquarium, therefore, depend for their essential needs like shelter, food, etc., on their environment.

This fact would then lead to the following questions :

(a) are some parts of the environment more favourable than others to a species ?

(b) if so, would that cause an uneven distribution of organisms ?

Answer to these questions can be found only if we know something of the importance of water.

The ecosystem

A community. From your observations and studies of life in the aquarium, it is now possible to draw some inferences.

(i) All organisms belonging to one species and living in a single locality would seem to constitute a *population.*

(ii) Populations of several species in a given locality, would then constitute a *community.*

(iii) A community made up of several species of organisms taken alongside with the physical and chemical factors of the environment, in which they live, could be regarded as an ecological system or *ecosystem.*

The population, the community and the ecosystem, therefore, represent three important levels of biological organization. Ecology is the study of the relation between organisms and their environment and includes an understanding of the interaction between organisms in a community.

It is reasonable that the members of a community interact with one another. A small behavioural and adaptive change, in one part of the community, may have far-reaching consequences. For example, complete elimination of larvicidal fish like *Gambusia* sp. from a sheet of fresh water may lead to an unchecked increase of mosquito larvae. Greater the amount of mosquito larvae, greater will be the growth of adult mosquitoes along with the consequential health risks.

When the number of individuals of a given species does not change dramatically in a given habitat, such communities are considered *stable*. When the reverse is there, they are *unstable*. We need to know, therefore, the biology of communities so that we could predict how communities respond to external changes.

The community of organisms in an undisturbed pond may be little influenced by man. This community is called a natural one. In contrast, the composition of any aquarium community is determined by the person who sets up and cares for it. This is, therefore, an artificial community.

The study of the aquarium in the class room, however, gives us a fair idea of the nature of life in water. We shall now study a little about organisms in water under natural conditions (in contrast to the aquarium established with human effort).

Organisms in water

Organisms in water are not arranged in any regular or taxonomic order. In fresh water ponds or lakes, organisms may be classified, based on either their mode of life or according to the regions inhabited by them.

Based on their mode of life they may be classified as follows :

Benthos : Organisms living attached to or resting at the bottom, e.g., *Chara*, *Vallisneria*, bacteria, larvae of beetles (Fig. 1.1). Organisms attached or clinging to stems and leaves of rooted plants or on surfaces which project from the bottom of the pond or lake, e.g., *Hydra* (Fig. 1.1, 1.2).

Plankton : Floating organisms whose movements are more or less dependent on currents of water, e. g., diatoms, and motile forms like *Chlamydomonas*, etc. (Fig. 1.1).

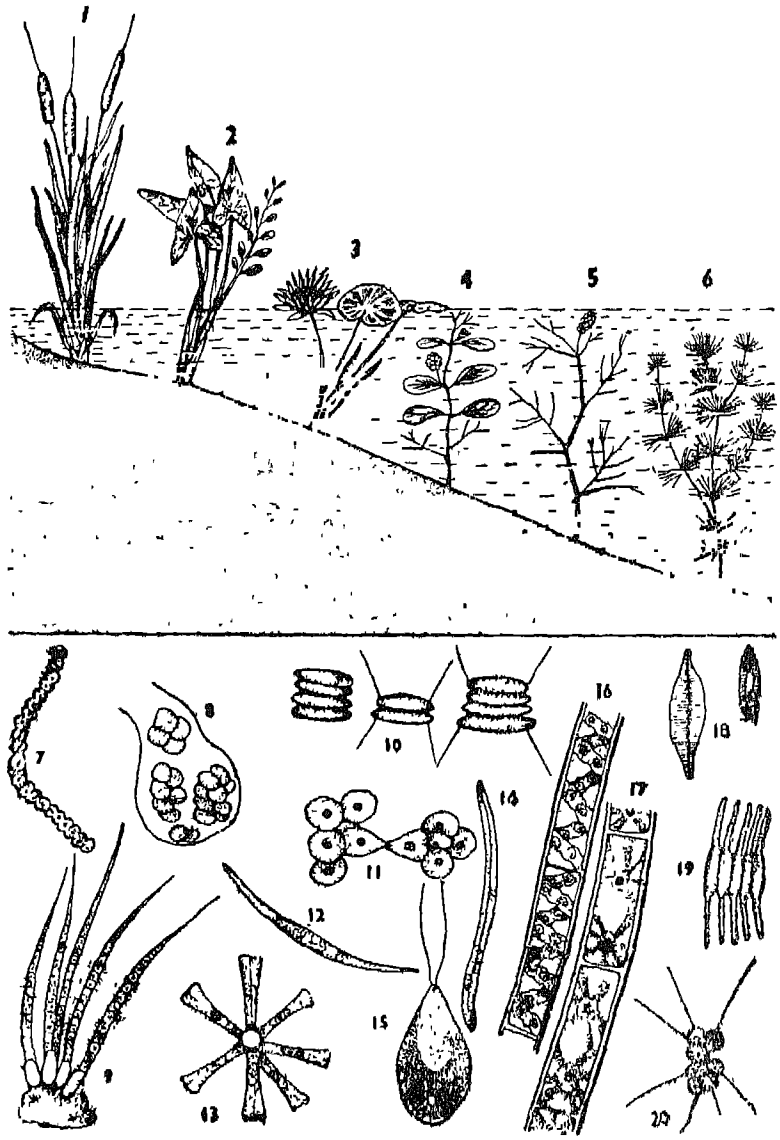

FIGURE 1.1 Some plants found in fresh water. (Not to scale. The emerging, floating and submerged plants are shown)

1. *Typha*, 2. *Sagittaria*, 3. *Nymphaea*, 4 and 5 two species of the pond weed *Potamogeton*, 6. *Chara*, 7. *Anabaena*, 8. *Microcystis*, 9. *Gloeotrichia*, 10. *Scenedesmus*, 11. *Coelastrum*, 12 *Closterium* 13. *Asterionella*, 14. *Nitzschia*, 15. *Chlamydomonas* 16. *Spirogyra*, 17. *Zygnema*, 18. *Navicula* 19. *Fragilaria*, 20. *Richterella*.

On the basis of their natural stratification, three zones are generally evident in ponds and lakes.

They are :

(a) *Littoral zone*—A shallow water region where bright to feeble light penetrates to the bottom occupied by rooted plants.

(b) *Limnetic zone*—A zone of open water up to the depth of effective light penetration. The community in this zone is composed of plankton, nekton and sometimes neuston. This zone is generally absent in shallow water ponds.

(c) *Profundal zone*—A region of bottom and deep water areas beyond the depth of effective light penetration.

The pond as an ecosystem : A small pond or tank is the simplest example of a fresh-water ecosystem. (Fig. 1.4).

In ponds the littoral zone is relatively large and the limnetic and profundal zones are small or even absent. Some ponds contain a large amount of organic matter. Temporary ponds, or those which are dry most of the year, are of much biological interest as they support a unique community. The organisms that live in those ponds possess an ability to survive drought and dry conditions (as the water usually dries up during the summer periods). These survive either by being dormant or inactive and protected against drought. Some amphibians and aquatic insects are able to move in and out of ponds.

1. Collect a sample of water from a shallow pond which is fairly rich in vegetation.
2. Take a few ml of water and centrifuge in a hand centrifuge. Examine the sediment and the supernatant centrifuged liquids under a microscope.
3. Make drawings or sketches of what you notice and identify them using the figures or with the help of your teacher.

The figure (1.2) would give you an idea of some organisms found in such temporary ponds in different parts of the year.

Streptocephalus, seen in most fresh water ponds, are remarkable in their adaptation to the environment. The eggs of fairy shrimps survive in the dry soil for many months, whereas development, maturity

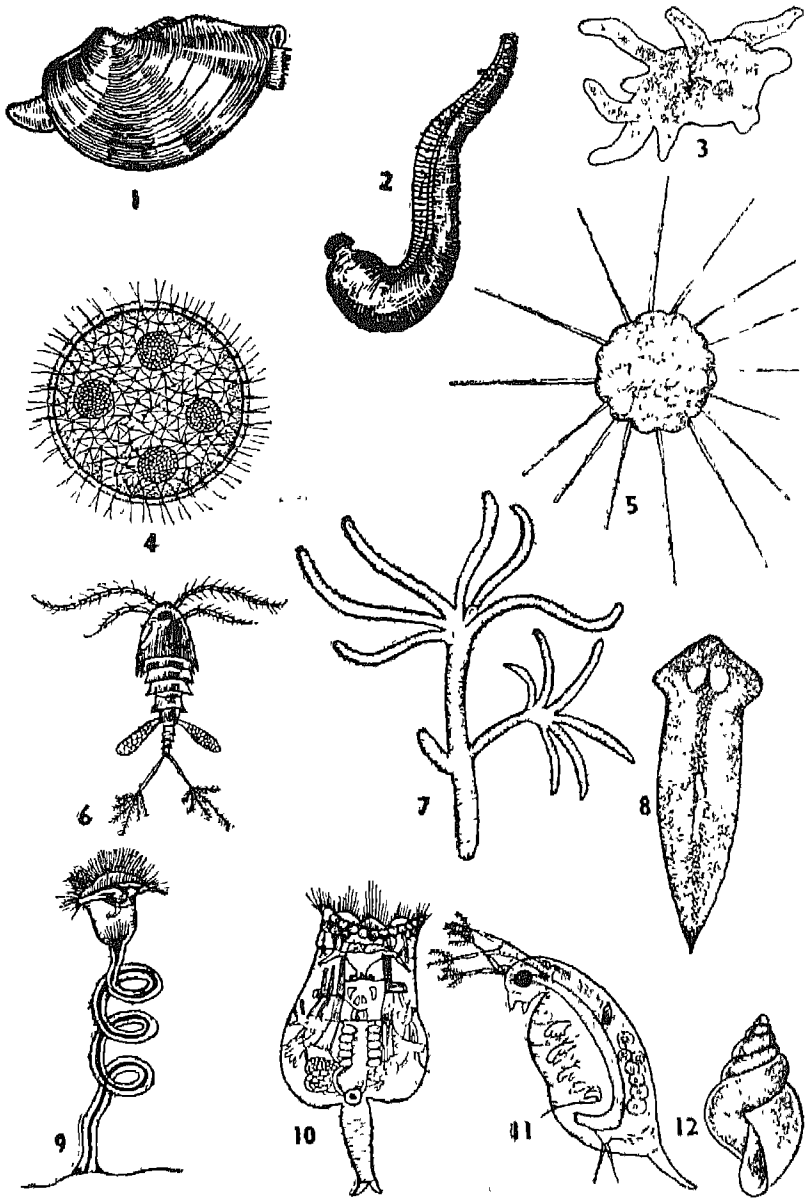

FIGURE 1.2 Some fresh water animals. (Not to scale).
1. A clam, 2. A leech 3. *Amoeba* (highly enlarged) 4. *Volvox*. 5. *Actinospaerium* (enlarged), 6. *Cyclops*, 7. *Hydra*, 8. *Planarian*, 9. *Vorticella* (enlarged), 10. Rotifer, 11. *Daphnia*, 12. *Lymnaea*.

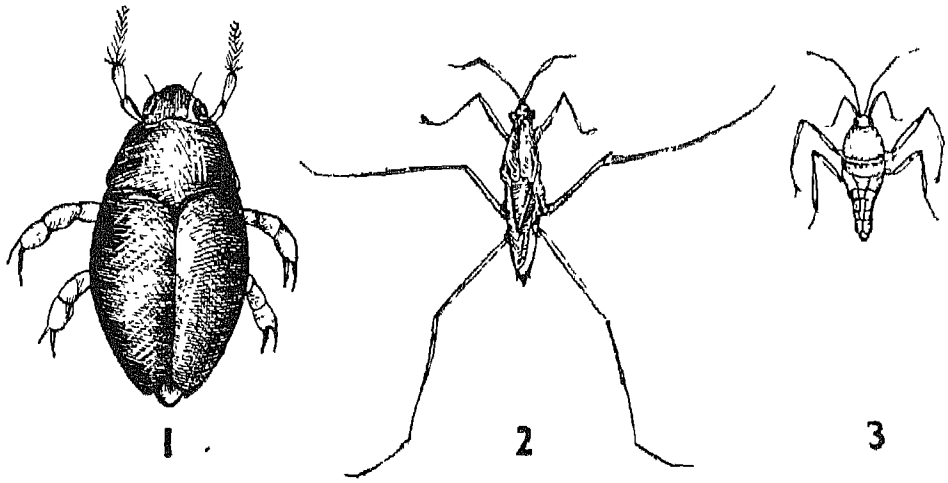

FIGURE 1.3 Some aquatic insects.
1. Water beetle, 2 & 3 Water striders.

and reproduction occurs only when water is available. Even though a temporary pond contains water only for a limited period, there is a seasonal variation of succession of different types of organisms which flourish in such ponds at different times. This enables a surprisingly large variety of organisms to utilize the resources of a limited physical habitat.

Factors that limit life in fresh water habitats

In a fresh water ecosystem the following are likely to be the limiting factors in the life of organisms.

(*i*) *Temperature*

(i) In the aquarium set up in your class room, measure and note the temperature in the following areas :
(a) below the bottom mud ;
(b) at mid-depth of the water in the aquarium ; and
(c) at the surface of the water.
(d) the room temperature.

Changes in temperature occur slowly in water than in air. Further, in very cold climatic regions, water freezes only on its surface. As

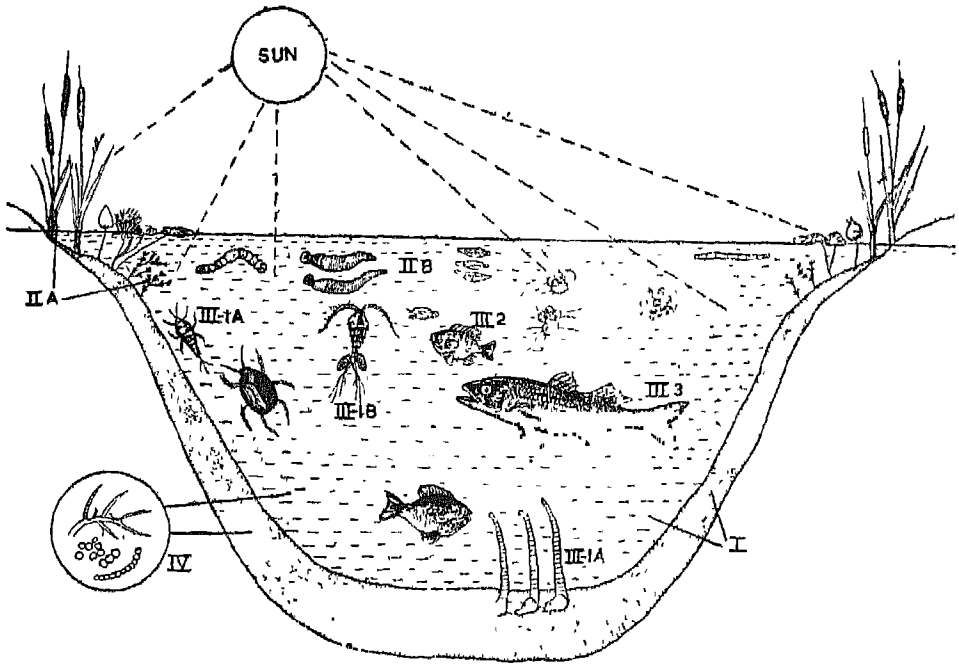

FIGURE 1.4 A pond ecosystem (after Odum).
I—The non-living or abiotic organic and inorganic substances
II A—Producers—rooted plants.
II B—Producers—phytoplankton.
III-1A—Primary consumers (herbivores.)—bottom living.
III-1B—Primary consumers (herbivores.)
III-2—Secondary consumers (carnivores.)
III-3—Tertiary consumers.
IV—Decomposers—bacteria, fungi, etc.

aquatic organisms tolerate only a very narrow range of temperature, this physical environment becomes a major limiting factor. It is also known that there are exceptional cases where hot springs support a wide variety of life.

(*ii*) *Turbidity.*

Penetration of light is often affected by suspended materials in water. This restricts photosynthetic activity of many aquatic organisms. Turbidity, therefore, is another important limiting factor.

(iii) Other Factors

Water currents, concentration of respiratory gases like CO_2 and O_2 and concentration of salts are other limiting factors. Moreover there is always an accumulation of waste products, produced by the organisms, stale products that enter into the water from outside and other substances of a harmful and toxic nature. These are also limiting factors that restrict the life in fresh water.

Biology of life in freshwater habitats

It will be of some interest now to know something about the nature of life in fresh water habitats. Freshwater habitats are basically of two types *still*, like lakes and ponds, or *running*, like rivers and streams.

Lotic (running water) communities

A comparative study of life in a stream and pond is an ideal ecological investigation. The main differences between still and running waters are as follows :

(i) Water current has a major influence in controlling and limiting the nature and pattern of organisms in running waters, e.g., fishes that live in rivers exhibit a characteristic distribution in running waters. Fishes generally swim against the direction of the current. The flow of water in lotic habitats is more rapid in the upper reaches of rivers whereas in the lower reaches of the rivers the flow of water is so slow that it appears to be almost still.

In the upper reaches of rivers, the flow of water is so rapid that, in places or areas like waterfalls, the flow of water is almost vertical. In such situations like waterfalls and torrents, larvae of insects are provided with modified discs or hooks in their thoracic legs to enable them to cling safely to hard surfaces and prevent being carried away by the fast flowing water (Fig. 1.5). Rooted plants are less abundant where the current is fairly rapid or fast, vegetation being generally restricted to the sides.

(ii) *Oxygen :* Streams and rivers generally contain oxygen, even when there are few or no green plants. This is

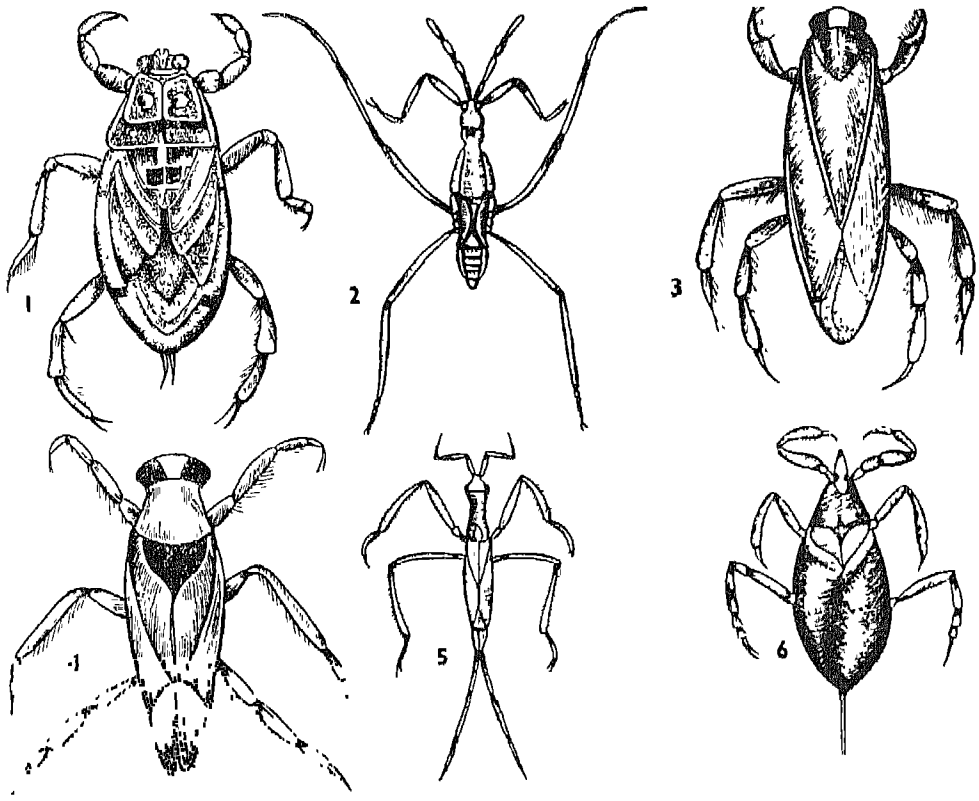

FIGURE 1.5 Some aquatic insects.
1. *Bellostoma*, 2. *Gerris*, 3. *Corixa* 4. *Laccotrephes*, 5. *Notonecta* 6. *Nepa*.
(*Note*.—Some of these insects are provided with hook-like projections in their thoracic legs to cling to some support in running waters.)

due to the large surface of water exposed to air and the constant movement of the water. Animals that live in streams are not able to tolerate or withstand even a slight reduction in oxygen content.

The organisms in lentic (or still water) communities

Some of the green algae like *Cladophora* (see Fig. 1.1) which have a filamentous body, live attached to a substratum like a stone or other solid objects. Freshwater sponges also cement their bodies to a substratum. Some insects are provided with suckers for attachment. Snails and

flatworms adhere firmly to substrata using their sticky undersurfaces. The bodies of animals like fishes which swim about actively in freshwater are streamlined. The most characteristic feature of lentic communities is the relative absence of plankton.

Some general notes on organisms that live in freshwater

(a) *Plants :* A large variety of plants are seen in freshwater. These include many algae together with a number of fungi, bryophytes, pteridophytes and angiosperms that have become adapted to the aquatic mode of life.

The algae are predominantly aquatic plants which abound in fresh water. The common freshwater algae are the diatoms, blue-green and green algae, desmids, *Chara*, *Spirogyra*. Some of the higher plants have become adapted to life in water, such as, *Typha*, *Limnophila*, *Ammania* sp. etc., but, by far the most interesting group of angiosperms are those that are living partially or completely submerged in water, e. g., *Vallisneria*.

(b) *Animals :* The protozoans like *Amoeba*, *Paramoecium*, *Euglena*, etc., and coelenterates like *Hydra* are common inhabitants of freshwaters. *Hydra* is usually seen growing attached to twigs or leaves submerged in water. *Planaria* which are freshwater forms are generally bottom dwellers. Leeches are common in fresh water and they generally feed on the blood of vertebrates. Snails of various species live in freshwaters. The freshwater mussels are bottom dwellers in freshwater tanks and ponds. Many crabs and prawns are adapted to a freshwater habitat. Insects are very common in freshwaters and many of them spend their larval stages in water. Amongst the vertebrates, fishes and frogs are most abundant in freshwater and the latter generally avoid moving waters. Crocodiles occur in some of our major rivers.

Pollution

Man has dug numerous water channels and canals. He has

dredged them deeper. He has, however, increased problems of pollution, by letting great masses of unwanted material such as sewage, industrial wastes, etc., discharge into flowing channels or rivers. Most of these substances positively affect life in water. Waters that contain such harmful material are said to be polluted.

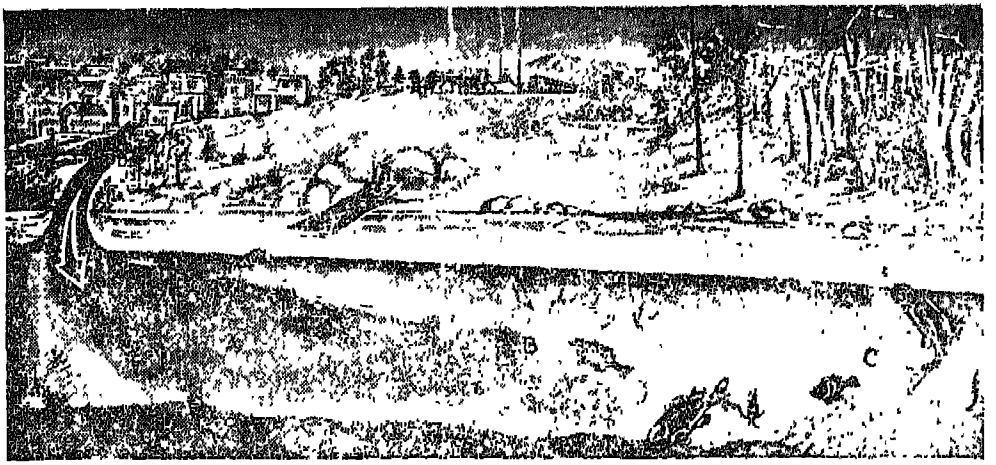

FIGURE 1.6 Sewage pollution of a river.
A : Sewage containing organic nutrients
B : Sewage acted upon by decomposers Oxygen supply decreases. Aerobic organisms perish.
C : Sewage decreases. Oxygen supply increases Phytoplankton also increases. Consumers flourish.

A small volume of sewage is no doubt helpful for the growth of producer organisms ; but not large volumes emptying into rivers and streams. (Fig. 1.6).

The sea as an aquatic habitat

The unique importance of water from the biological point of view lies in the strong assumption that life must have initially originated in the sea. Biologically speaking the sea supports a greater measure of life (Fig. 1.7) because it covers nearly three-fourths the surface of the earth. Literally, man has been exploiting only the surface of the ocean for his food.

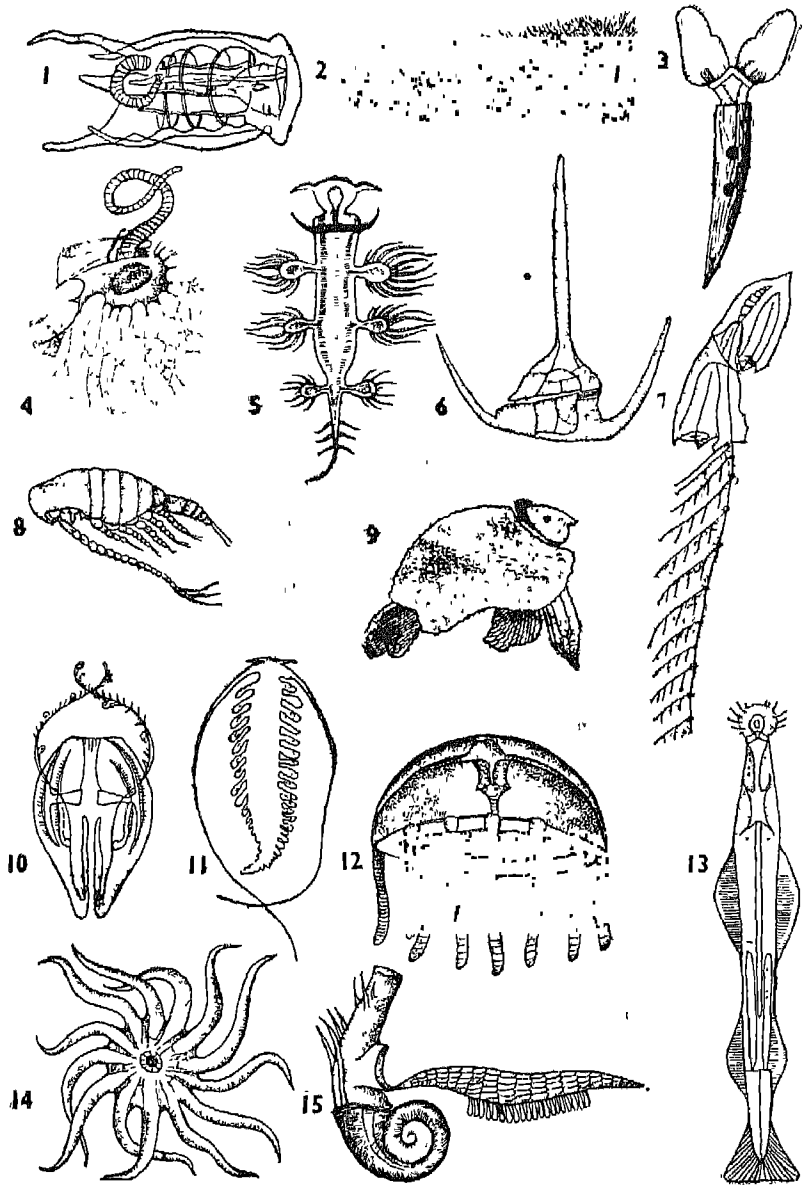

FIGURE 1.7 Some planktonic and pelagic organisms from the sea.
1. *Salpa*, 2. *Pyrosoma*, 3. *Creseis*, 4. *Noctiluca*, 5. *Glaucus*, 6. *Ceratium*, 7. *Diphyes*, 8. *Calanus*, 9. *Carinaria*, 10. *Pleurobrachia*, 11. *Tomopterus*, 12. Jelly-fish, 13. *Sagitta*, 14. *Pelagothuria*, 15. *Ianthina*.

One of the major differences between the waters of the sea and freshwater lies in the relative content of dissolved substances in the two media. A litre of sea water contains about 35 g of dissolved salts of which 28.5 g is sodium chloride, 3.66 g magnesium chloride and the remainder are mainly salts of potassium and calcium. In contrast, inland waters are relatively deficient in salts. The salt concentration really indicates that the osmotic concentration of sea water is appreciably greater than that of fresh water. You have already learnt (Book II, Chapter IV) how animals in the sea and in freshwater counteract this problem.

The ocean depths are a special type of an environment requiring particular adaptation for organisms to survive at these depths. It is cold and dark at great depths. There are no producer organisms at such depths. Food is scarce and the organisms that live at great depths depend on food settling down from above. Most animals in these zones are either black or dark red in colour and have the ability to emit light from their bodies. These animals have very sensitive eyes. Bioluminiscence is useful to a deep sea dweller either to lure a prey or help it to escape or for being spotted in that dark environment. Due to absence of other types of food, deep sea animals are mostly predatory (Fig. 1.8).

The coast line

The coastal region of the sea is also generally referred to as the littoral zone. The coasts or shores may be either rocky, sandy or muddy. The environment of the coast line is highly variable both in the salinity of the sea water and in the variations of the availability of sea water due to tides.

The organisms on the coast also exhibit a variety of structural modifications. Plants are not generally seen where an unstable sandy substratum exists. Many of the animals that live in sandy locations, however, are capable of burrowing into the sand. They include worms like *Arenicola* which lives in a 'U' shaped burrow and feeds like an earthworm. Amphipod crustacea like *Hippa* and *Albunea* also live in the sand by burrowing. Bivalved molluscs like *Cardium*, *Donax* and *Solen* (Fig. 1.9) are perhaps best adapted for life in such a soft sub-

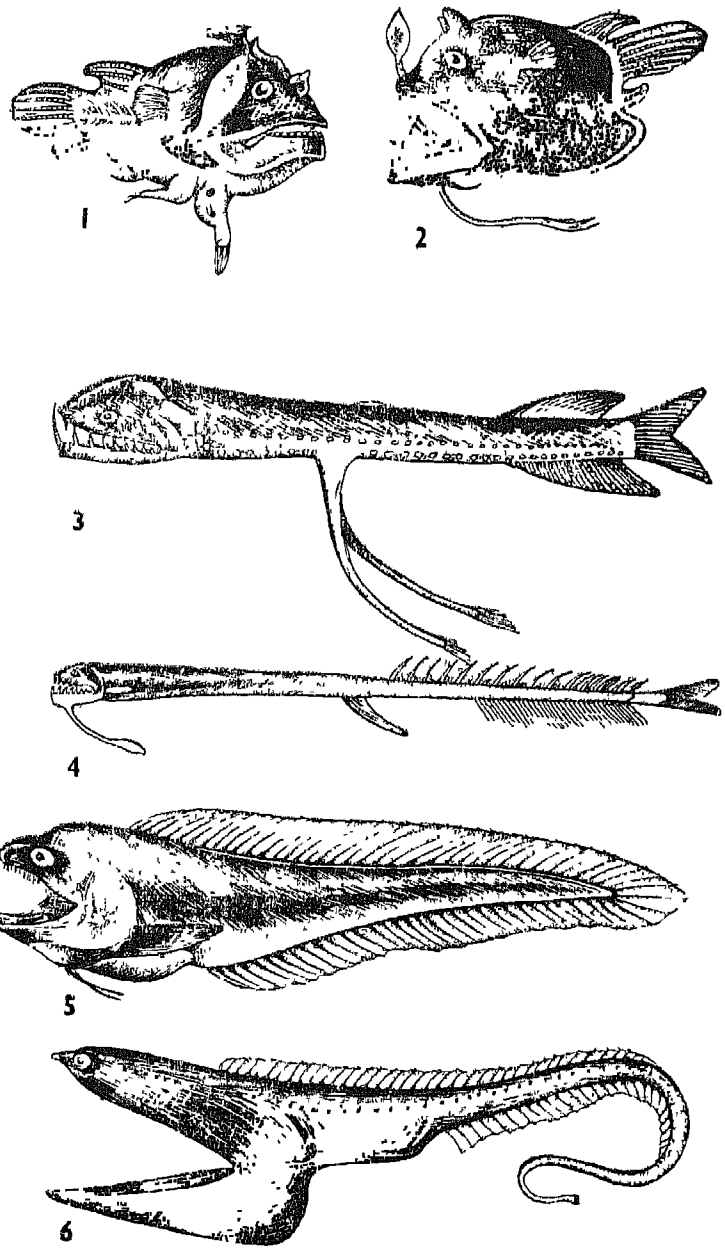

FIGURE 1.8 Fishes of abysmal depths.
1. *Endriolychnus* 2. *Linophryne*. 3. *Photostomias*, 4. *Idiacanthus*, 5. *Bassogigas*, 6. *Gastrostomus*.

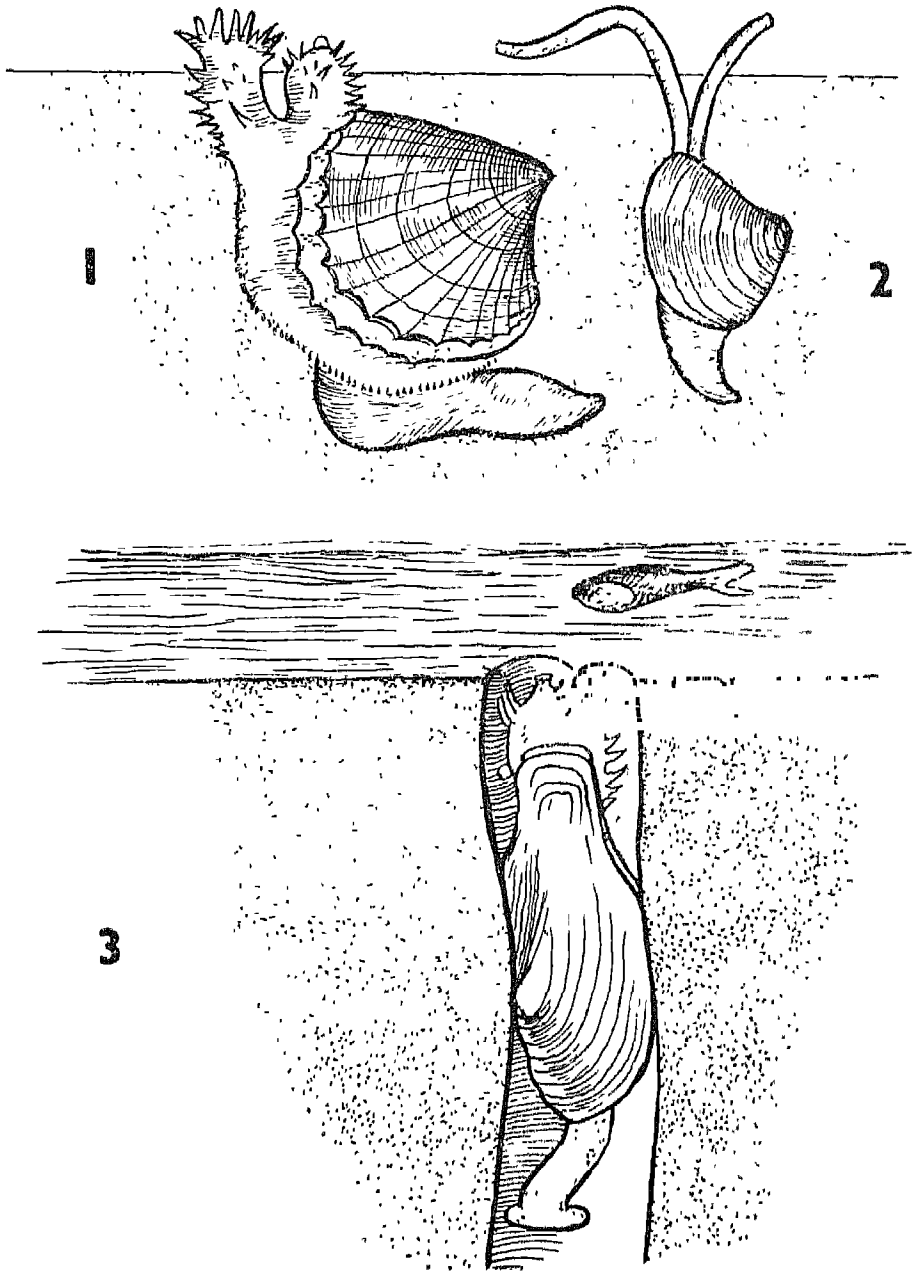

FIGURE 1.9 Some animals in inter-tidal sandy soil.
1. *Cardium*, 2. *Tellina*, 3. *Solen*.

stratum. Most of these burrowing forms of animals subsist on organic waste in the substratum.

Sometimes the coasts are rocky containing either pools of sea water in rock craters or submerged or exposed rocks and stones.

The rocky pools vary largely in their size or area and usually contain a considerable amount of sea water. Sponges and sea anemones are of common occurrence in sea water in our coasts. Small prawns or lobsters like *Homarus* can also be found. Attached to the rocks are various types of algae and their dense growth shelters many sedentary animals. The rocks and stones which lie loose and submerged in sea water offer shelter to a large variety of animals, whereas the crevices and the holes in the rocks serve as abodes for animals like *Pholas* (rock borer) and polychaete worm like *Eunice*.

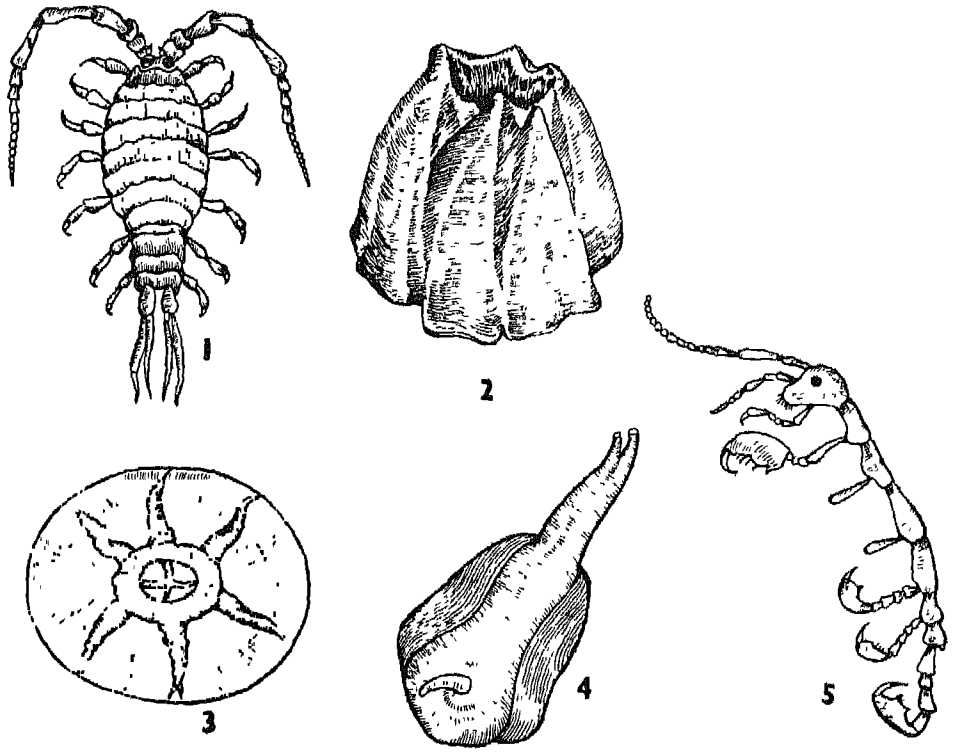

FIGURE 1.10 Some shore dwelling animals.
1. *Ligia*, 2. *Balanus* (usually seen on rocks or similar surfaces on the coast), 3. *Chelonobia* 4. *Saxicava* 5. *Caprella*.

The sedentary mode of life in these marine littoral animals (Fig. 1.10) has resulted in the loss of locomotor organs as in *Mytilhs*, or development of an ability for rapid contraction of their bodies when conditions are unfavourable or when disturbed as seen in the barnacle, *Balanus*.

Estuaries

An estuary is a zone of brackish water formed when fresh water and sea water come into contact, e.g., where a river joins the sea. The mixing up of fresh and sea waters in the estuaries, affects the character of this aquatic environment in a variety of ways. The salinity of the water fluctuates depending on the duration of the flow of water. It is less if a large volume of fresh water flows down the river into the sea and more, if during high tides, a larger volume of saline water enters into the estuary from the sea. Salinity also varies with depth in estuaries. Further, the bottom of an estuary is loose and muddy. It is seldom firm and has a tendency to be shifting. This prevents, to a large extent, animals and plants from getting a firm hold of the substratum and leading a sedentary life. It also happens that at some seasons of the year, the estuary is isolated from the sea by a bar of sand.

Generally aquatic plants are scarce in the estuaries. The common estuarine flora are *Juncus* and Cord grass on which many estuarine mollusca feed. Mangrove vegetation is specially associated with estuaries. A mangrove vegetation is characterized by the numerous pneumatophores (aerial roots for aeration) of trees like *Avicennia*, *Sonneratia* and *Aegiceras*.

In the case of organisms that dwell in the estuaries, they are always confronted with changes in the watery medium of the environment brought about in one of the following ways :

(i) Semipermeable membranes restrict the passage of salts to and from the body as in some polychaete worms like *Nereis*.

(ii) By having body fluids of greater osmotic concentration than the surrounding medium as in some fishes, e.g., *Hilsa*.

(iii) By having a major part or the whole of the body covered

by impermeable membrane, e.g., the eggs of some fishes.

The life of the estuarine dwellers is perhaps the most unenviable, in that, they have always to confront a wide variety of environmental changes, all the time. Excepting for a few organisms that can regulate the concentration of their body fluids so as to correspond to the salinity of the estuaries most organisms in estuaries are migratory. How peculiar then is the life of the salmon fishes in the N. W. Pacific living most of their lives in the ocean! When mature they enter the rivers from the sea, swim upstream—each fish swimming to reach the exact stream where it was hatched. Here in these streams, the mature ones breed and die and the young ones swim down and reach the sea.

CHAPTER II

LIFE ON LAND

Soil as a medium of life

What we call soil is formed by the 'weathering' of rocks by which rocks break up. When heated the rocks expand. But during nights the temperature of the atmosphere comes down and the rocks shrink as they give up heat. During this process of expansion and shrinking the rocks break up into smaller bits. The latter are washed away by rain and wind. During this process they grind against each other and crumble to a fine powder. The plant and animal remains get mixed with the powdered or weathered rocks to form the soil.

Soil is the abode of many hundreds of living things. The soil organisms have to face a variety of conditions. The chemical and physical composition of the soil varies widely. The amount of water held by the soil and the amount of free gases available also vary. These variations are noticed not only in different regions but also in the same soil during different seasons of the year. The water content of the soil, for example, in the upper and lower layers differs according to the seasons. Life on land has to be adjusted or adapted to all these variations in order to last.

Examination of soil types

1. Your teacher will provide you with five samples of soil collected from five different localities.
2. Examine the samples of these soils kept in Petri dishes.
3. Observe their colour and texture.
4. Mix a little of the sample with water and find out the pH of

the solution using indicator papers. The range may be indicated as alkaline, acidic or neutral.

5. Interpret your results in relation to the physical and chemical variability of soils.

Water and land life

The amount of water available to land animals and plants depends on the rainfall in the area as well as on the availability of ground water. Where the rainfall is high and uniformly spread out, a dense vegetation develops culminating in a rain forest. The rain forest contains a number of trees, forming the upper storey of shurbs and undergrowth. Among the animals in the rain forest there are three kinds, the tree dwellers, surface dwellers and the fossorial members. (See Chapter III on Forest Life). If the rainfall is limited to one season in a year followed by periods of dryness the trees shed their leaves during the dry spell. Such a forest is named as deciduous forest. Where the rainfall is less and the soil does not retain water for long periods a low type of vegetation develops. Such forests abound in thorny plants and shrubs. The term scrub jungle is applied to this type. The arid regions do not support luxuriant growth. Drought resisting plants such as cacti (Fig. 2.1) and the euphorbias alone can grow on such land. This is the desert with an extreme type of climate. The desert animals are able to resist the heat and drought of the sandy wastes. They are able to conserve water by physiological means and forgo drinking water. The camel, the desert fox, desert wolves and the desert rats are examples of such animals.

Surface dwellers

As you have already learnt, plants are the most important life forms in the land habitat. They are the primary producers upon which the whole food pyramid is built. Plants exhibit extreme variations in form and function. There are very many minute forms such as the bacteria, algae and fungi. The bryophyta and the pteridophyta are plants much more organized and differentiated. Yet they cannot survive or carry out their reproduction unless they are covered up by a film of water. The gymnosperms and the flowering plants are the most conspicuous groups of land plants. They are well established by their roots

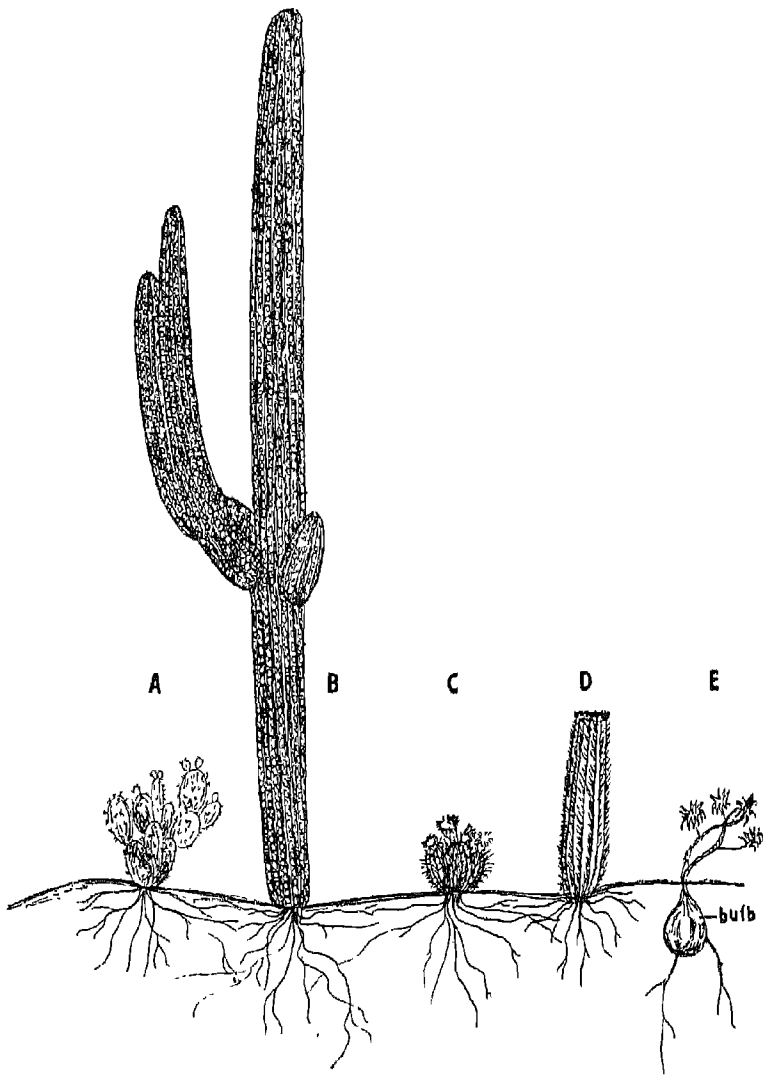

FIGURE 2.1 The different cacti that live in desert.
(A) Prickly pear, (B) Giant cactus, (C) Hedgehog cactus,
(D) Barrel cactus, (E) Night-blooming *Cereus*.
Desert plants make full use of the scanty water available.
They have developed spreading root systems which absorb as much rain water as possible.
The cacti store water in stems while some cacti store it in underground bulbs.
Cacti develop thorns to protect themselves from burrowing animals.

ramifying within the soil while their shoots spread out into the air to catch the energy of the sunlight. Plants take their position on land according to their structure and functions. For example, tall trees grow thick trunks and abundant foliage which could withstand the atmospheric heat. Consequently they provide protection from the heat and direct sunlight to such plants as can only thrive in shade and low light intensity. A thick growth of ferns, ground orchids and other shade loving plants is found under them. Still closer to the surface grow the algae, fungi, liverworts and mosses along with large populations of various small animals.

The development of locomotory organs in surface dwellers

Animals living in the sea move about by swimming or by floating passively, whereas living things on land develop entirely different types of locomotory organs. As you know, most of the land animals have legs for locomotion. They jump, creep or run with the help of their legs. Snakes do not have legs. They move by crawling on their ventral surface, with the help of the ventral scales and ribs.

The earthworms move on land by wriggling movements of their body. The small bristles called setae distributed all over the body help in holding to the slippery ground. The earthworm moves by remarkable contractions and expansions of its body.

Let us consider locomotion in the toad. The legs of the toad are not of equal size. The forelimbs are shorter than the hindlimbs. When the toad jumps it stretches its hindlimbs and takes a leap in the air. When it alights on the ground the forelimbs bear the weight of the body, for which they are designed.

The dog is an animal which uses all its four legs. The legs of the dog are slender and strong. The legs move in alternating rythms in motion and also support the body. The hoofed animals such as the horse and the deer possess long legs well adapted for running with speed on hard ground. The hoof of the horse is undivided whereas it is split or cleft in the case of the deer. These animals cannot run on sandy soil because their feet will sink deep. The hooves of cattle are also cleft. This ensures a sure grip. Cats walk on their toes. Their heel bones

do not touch the ground. Small pads on their feet cushion their walk and help them to move noiselessly.

Certain birds cannot fly at all. But they are capable of running very fast on land. They have special adaptations to effect this. The ostrich is an example of this (Fig. 2.2). It is found in grasslands of Africa

FIGURE 2.2 Ostrich, a desert bird.

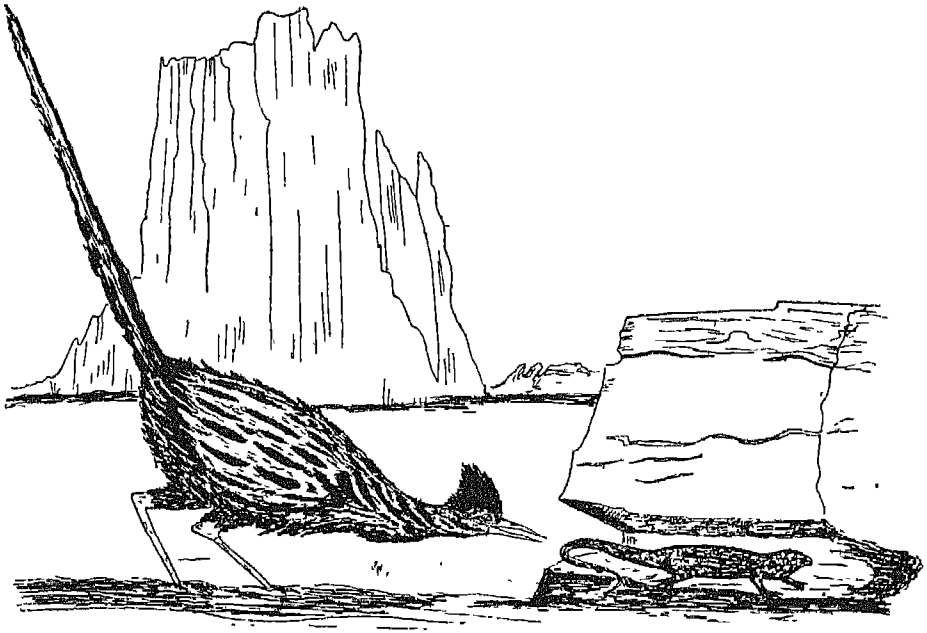

FIGURE 2.3 Road runner. This bird found in North American deserts lives on snakes and lizards. It can reach its prey right into the crevices in rocks. Its long claws are adapted for running on the desert.

and is a fairly heavy creature. Its legs are quite long and its toes are three in number. When pursued by enemies the ostrich can run at a speed of 50 kilometers or more per hour. The ostrich also spreads its wings while running. This helps the bird to maintain its balance. The road-runner is a smaller bird (Fig. 2.3) found in deserts of the North American continent. It is lighter in weight and is often seen running very fast on desert roads. Like the ostrich its legs are very long and its claws short to make running easy. The bird hunts small vertebrates like desert lizards and snakes. It is seen chasing lizards in the desert. In our country the jacana is often found walking on muddy flats. One can see the foot prints of the jacana near lakes or spreads of water. The toes of the jacana are pretty long and this feature helps the bird in walking on soft mud without sinking.

The limbs of young ones of the land animals are rather longer than those of the adults when we compare their body size and limb

length. This not only helps the young animals to reach the udder of their mother but also in running fast so that they can keep pace with their mothers when the herd is on the move in search of food and water or is running for its life against hostile creatures. This adaptation saves the life of young animals because they can also run as fast as the grown-ups.

Arboreal Life

You are familiar with monkeys which are mostly arboreal or tree-dwelling. These animals can move, feed and rear their young on trees. The body of the monkey is well adapted for this mode of life. Most monkeys have an apposable great toe which serves them in the same manner as the thumb on their hands. This enables them to grasp objects and branches with both foot and hands. Therefore the monkey can move even upside down on branches. In addition to this faculty the monkeys can jump from tree to tree by grasping the branches while in action. The New World monkeys have an additional adaptation for arboreal life. Most of them have tails called 'prehensile tails'. These are used in grasping the branches and balancing themselves in tree-top travel. Their toes are apposable and therefore well suited for holding the thinnest twigs. As a matter of fact they are so highly modified for an arboreal life that they are hardly able to walk on the ground. Snakes too live on trees. The green snake moves swiftly on branches and feeds on small mammals and birds and their eggs. The majority of snakes known as boas are arboreal and correlated with this habit the tail is usually more or less prehensile.

Even plants have taken to life on trees. The well-known examples are orchids and bromeliads. *Vanda* is an orchid which grows on branches of tall trees (Fig. 2.4). It sends down thick roots which hang in the air and absorb moisture. Some of these roots grow into the crevices of the bark of the host tree and anchor the plant firmly.

Conditions affecting Life on Land

In the land habitat water is available in several forms. Sheets of surface water are available in the form of oceans, ponds and rivers. Rain water soaks into the soil and collects in the subterranean strata.

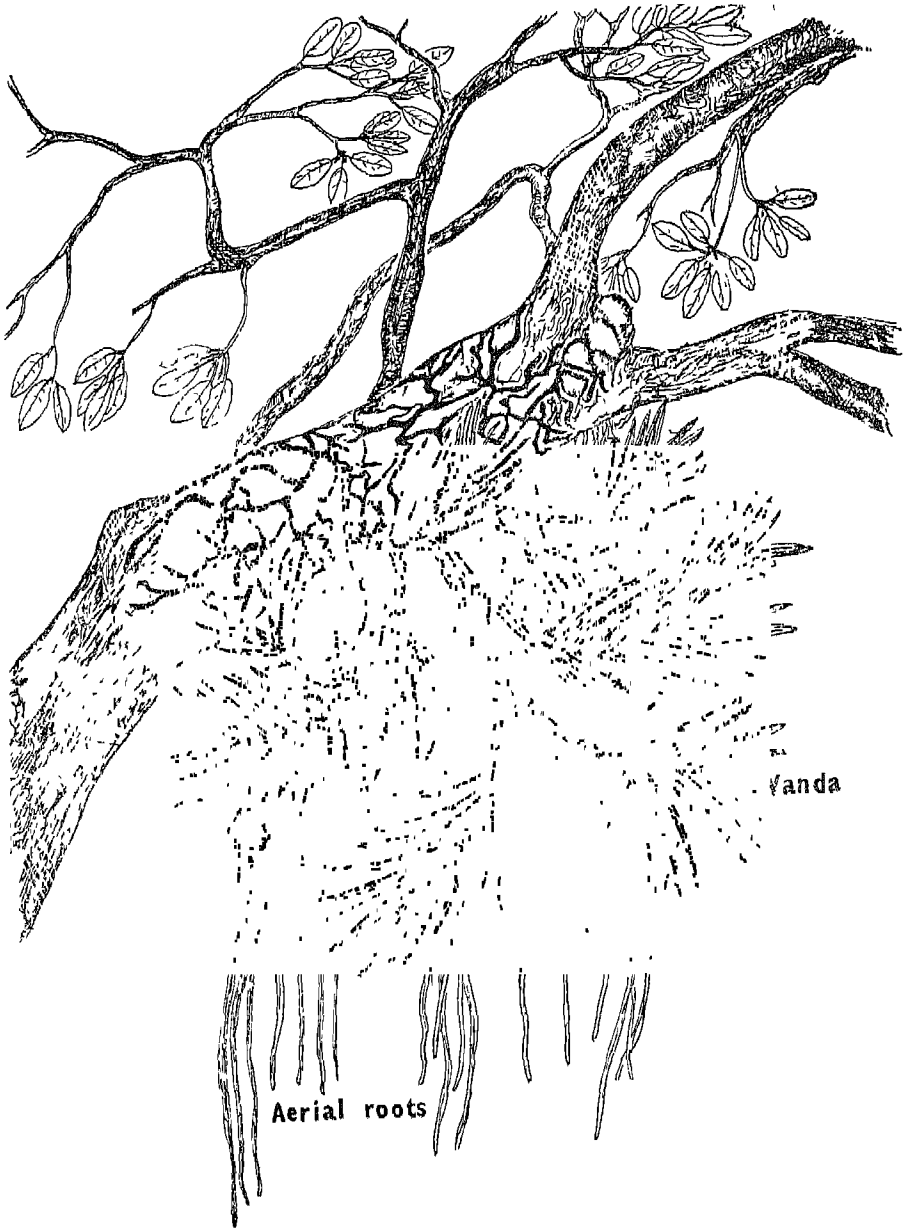

FIGURE 2.4 Vanda, an epiphytic orchid.

This forms the ground water source. Plants and animals make use of all these resources. The roots of trees reach deep layers of the soil and

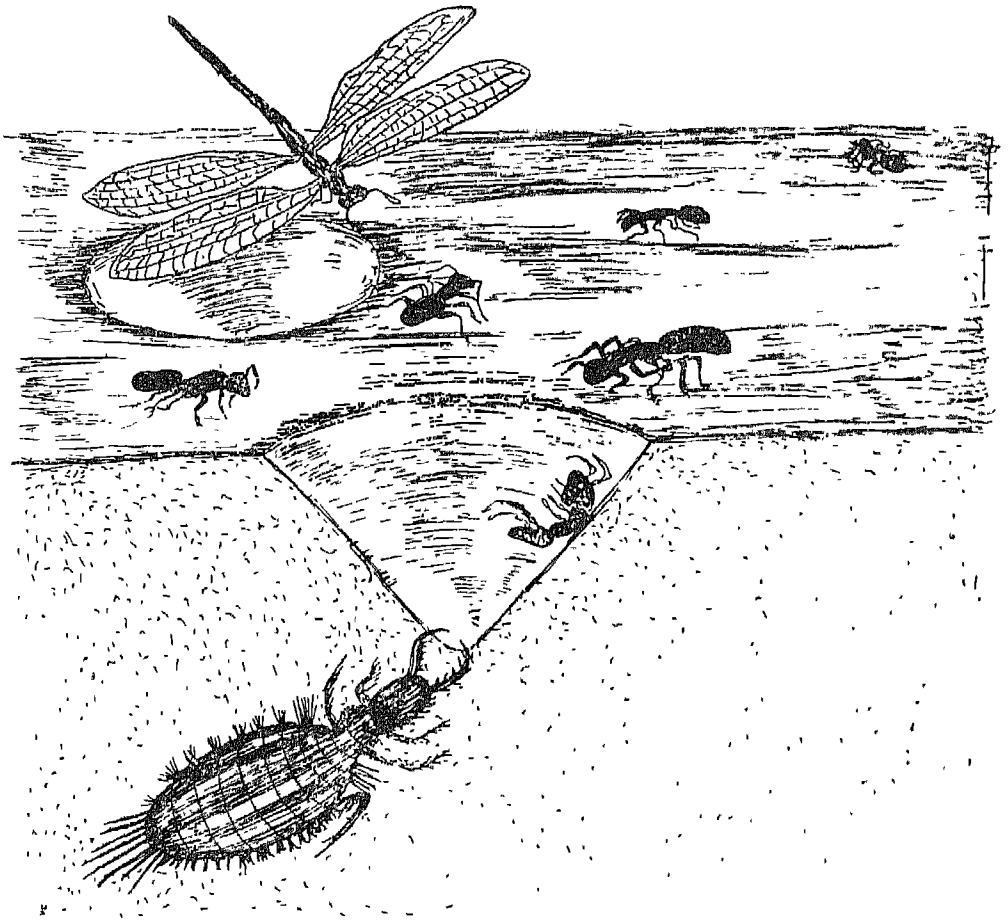

FIGURE 2 5 Some insects of dry areas. Ant lion larva in pit with adult fly above and some ants.

absorb the water. A number of insects inhabiting dry areas (Fig. 5) get their water from the dew.

Since water is a necessity of life, animals and plants cannot afford to lose it. Therefore they resort to several methods of water conservation. Frogs and earthworms secrete mucus which helps to keep their body moist. In the arthropods the outer cover of the body is impervious to water. The chitinous layer of these animals does not permit loss of water from the body. The reptiles have a scaly skin which prevents loss of water by evaporation from the body surface. In reptiles and birds the waste matter from the body is excreted in a semi-solid form

because, in the majority of cases water from the urine and excreta is reabsorbed in their bodies. This is the reason why their water requirements are very limited.

The water in plants is conserved by the formation of a thick cuticle on the aerial parts. The stomata on the leaves prevent excessive water loss by closing the stomatal openings. At a certain stage the loss of water in a plant may lead to drooping or wilting. A wilted plant may recover if watered at the proper time. Otherwise, it may lead to permanent wilting and death. Different plants have different tolerance for wilting. Broad-leaved plants cannot stand too much of dry periods. A leafless plant like the cactus can withstand desiccation more effectively. Some trees shed their foliage in a particular season to avoid loss of water through their leaves.

Plants produce seeds which contain the embryo in a dormant stage. The seeds are mostly dry and are capable of surviving for long periods during drought. When the wet season sets in, they germinate. The reptiles and birds lay eggs covered with hard shells which do not allow loss of water from within.

Some plants undergo a condition called anabiosis. This means that they look like crumpled dry matter when moisture is lost from their body. But when a little water is sprinkled they regain their green colour and become fresh. Lichens and mosses are very common examples of such plants. *Selaginella*, a club moss also shows this condition. Some species of algae undergo anabiosis. The species of *Rofatona* and *Tardigranda* are other examples of plants showing anabiosis.

Land Life and Air

Land plants and animals depend on air for their survival. Air supplies the most important life-giving gas, oxygen. Air also contains carbon dioxide which the plants utilize in photosynthesis to produce carbohydrates. The carbohydrates or sugars are the starting point of food chains and are thus the energy donors to all forms of life. Thus air plays a vital role in maintaining life on land.

Several lower forms of life like the worms are capable of taking in atmospheric oxygen through their skin by way of diffusion. The carbon dioxide given out during respiration is released into the atmosphere through their skin.

Even animals which live in underground tunnels need air for breathing. For example the rats which live underground commonly

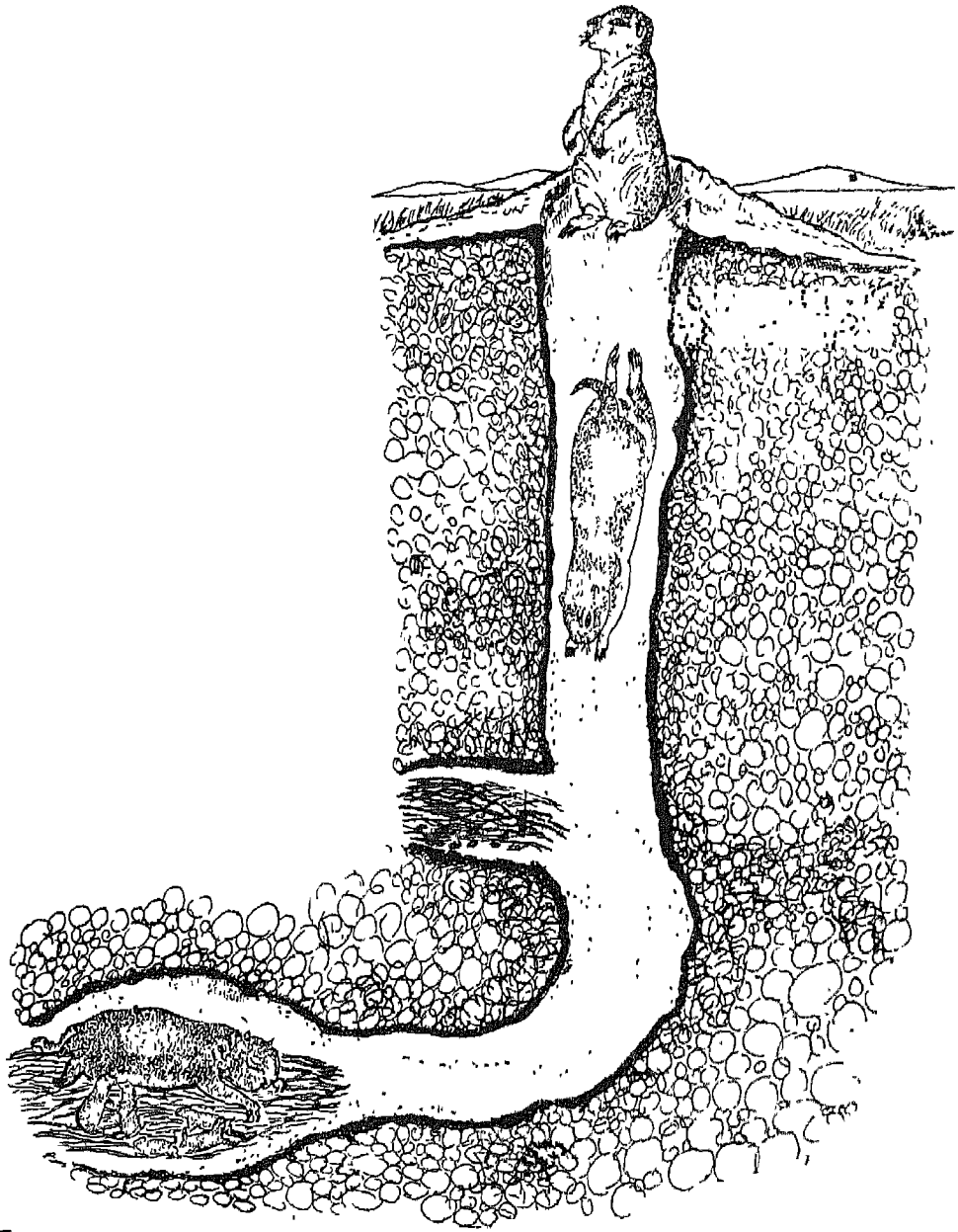

FIGURE 2.6 Prairie dogs living underground in burrows. The burrows open at ground level through which air enters uninterruptedly.

called prairie dogs and inhabiting the priaries in North America, always make open holes through which the air enters the burrows (Fig. 2.6). Continuous supply of oxygen is thus ensured. Among the plants the mangroves are well known for their breathing roots which project over the mud to take in fresh air. These are called the breathing roots or pneumatophores. *Avicennia* and *Rhizophora* are two species of mangroves which exhibit numerous breathing roots around the bottom of the trunk and jutting out of the muddy water. Each such root has numerous pores through which air enters the plant.

Temperature and land life

Temperature is one of the physical factors that affect life in general. Extremes of temperature are always deterimental to plants and animals. However, life has been existing in hot deserts and cold frozen arctic regions, because the animals and plants inhabiting these areas are highly modified in their structure and habits so as to withstand such extremes of heat and cold.

Animals living in cold regions develop fur which insulates the body and helps to preserve body heat. The yak from the higher altitudes of the Himalayas (Fig. 2.7) has long dense hair on its body. A layer of fat

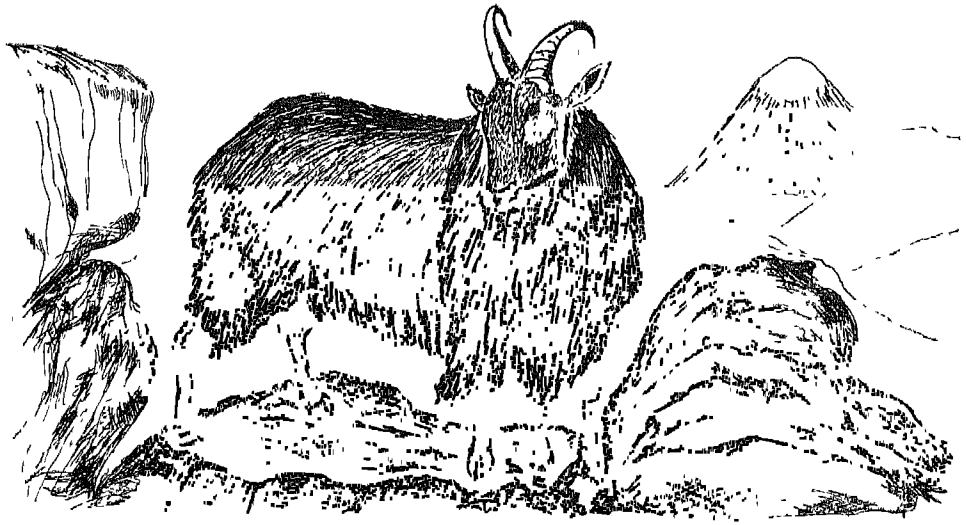

FIGURE 2.7 A yak from the higher altitudes of the Himalayas. It has long dense hair on its body.

deposited under the skin of these animals also serves to maintain body temperature within tolerable limits. Similarly, the reindeer (Fig. 2.8) found in tundras has a thick furred skin with fat deposited under the skin

FIGURE 2.8 Reindeer, an animal of the tundras used extensively by the Eskimos.

which helps in insulating body heat. This animal is very valuable for the people living in these parts (eskimos) who make use of them for food and for pulling sledge.

The bears, seals and walruses (Fig. 2.9) are examples of animals which are able to resist cold in this way. Some animals of the intense cold regions undergo inactive phases in their life called hibernation. Hibernation is the suspension of the activities of the body in a state of rest found in animals of the cold region. In the animals of the hot regions of the earth a similar condition is known to occur. This is called aestivation.

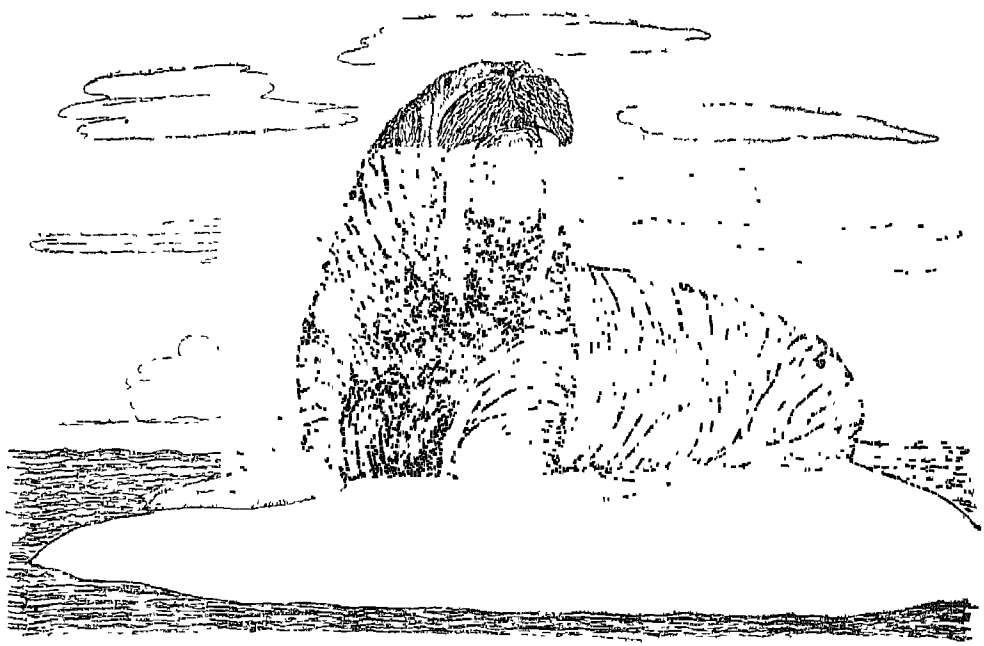

FIGURE 2.9 Male walrus found in the snowy arctic region.

The extreme heat of the desert poses different problems. Animals inhabiting these regions have to keep their bodies cool so that their body temperature does not rise to a dangerously high level. Cooling is usually obtained by the evaporation of water from the body surface. The sweat glands secrete sweat which cools the body as the moisture evaporates from the skin.

Desert rats burrow into the ground and spend the hottest part of the day underground. The land turtle or tortoise, the desert fox and many lizards hide during the day and come out only after dusk. Thus, they avoid contact with the extremes of heat and dryness of the atmosphere. Frogs, for example, bury themselves into the mud and aestivate when the pond is drying. When the monsoon sets in they come out and become active again. All these help in the survival of these species.

Birds are well known for their habit of migrating to warmer parts of the globe when the temperature goes down. They return to their original place when the temperature becomes favourable again. A number of birds migrate to India from Central Asia during the winter and return in summer.

Desert Life

The desert is an extreme type of habitat. Usually deserts are known as very dry areas where rain is very scanty. Drinking water is extremely difficult to obtain in the desert. The days are very hot and the nights very cold. In spite of the extreme heat and cold, a number of animals and plants found in this habitat are highly adapted to such conditions. The desert soil may not always be sandy, it may be composed of mud and clay, rocks and stones or a mixture of these.

Conditions of desert life

The desert soil : You have studied in earlier classes that the soil is an important constituent of land. The soil supports plant life and consequently animal life. The common garden soil consists of clay, fine and coarse sand and organic matter. What is peculiar about the desert soil ? A desert tract may consist of clay alone or may have large stones. It may consist of huge deposits of coarse or fine sand. A desert which is dry in summer may turn into a green lush area in the spring. In some depressions in the sandy desert the ground water may be found in good quantities. These are the oases. Here long-rooted palms grow in clumps. Birds like pigeons, sand grouse as well as rodents gather in such places.

Deserts occur in all continents (Fig. 2.10). The largest desert of the world is the Sahara which stretches across the whole 5120 kilometers width of North Africa and occupies nearly a third of the entire continent. It is almost as large as the continent of Europe including Great Britain.

The great Thar desert stretches east of the river Indus and occupies an extensive area of Western India.

Plant cover and the land

You have already learnt that plants colonized the land first and that animals followed. This happened during the remote geological periods. How does the plant cover affect the land and its structure? Here is a simple experiment to study this aspect.

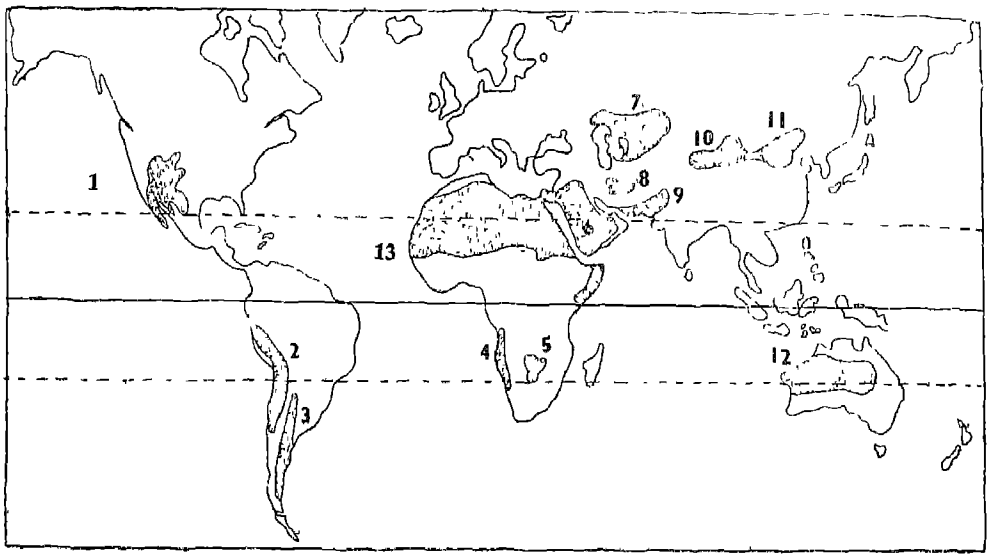

FIGURE 2.10 Deserts of the world.
(1) North American (2) Atacama (3) Patagonian (4) Namib (5) Kalahari (6) Arabian (7) Turkistan (8) Iranian (9)Thar (10) Taklamakan (11) Gobi (12) Australian (13) Sahara.

Experiment

Select a plot of land in your school garden. Divide it into two plots A and B. Remove all the plants in one of these and retain plants in the other. Record the temperature of the soil in both the plots in the morning, noon, and in the evening and record the same in the table given below :

Time	*Temperature in °C*	
	Plot A with plant cover	*Plot B barren*
8 *a.m.*		
12 *noon*		
5 *p.m.*		

Make the graphs showing the daily variations of temperature in both the plots. Answer the following questions :

(a) Is there any temperature variation in the two plots ?

(b) Why does the plot without plant cover show higher temperature ?

(c) How does plant cover provide congenial temperature conditions for animal life ?

The deserts are the homes of an amazing variety of plants and animals which have developed the ability to thrive under conditions of extreme heat and dryness.

Desert Plants

The plants of the desert are peculiar in one way or the other since they have to resist loss of water and conserve whatever water they already have in their tissues. They assume diverse shapes and are mostly without leaves. (Fig. 2.1). Some of them are rounded, some flattened and yet others stand as tall columns. In these plants the leaves are modified as spines. Is there any advantage in having these peculiar shapes ? If you cut these plants you will find them fleshy and watery inside.

Desert animals and water

(a) Water holes and oases in the desert are visited by various animals and birds. Some desert birds fly long distances to drink water. Others live close to water sources. The little pintailed sand grouse of Punjab and Rajasthan can fly several miles to drink water. They visit the water holes at dawn almost regularly. The trumpeter bullfinches of Sind drink both in the morning and evening.

(b) As the rainfall is very low and irregular in deserts few animals depend on it directly. However, the temporary pools of rain water have their own fauna of great interest. The small animals which are found in them complete their life cycle within a short period before the water dries up.

(c) Dew is a good source of moisture for many insects. It is known that insects and beetles drink drops of dew.

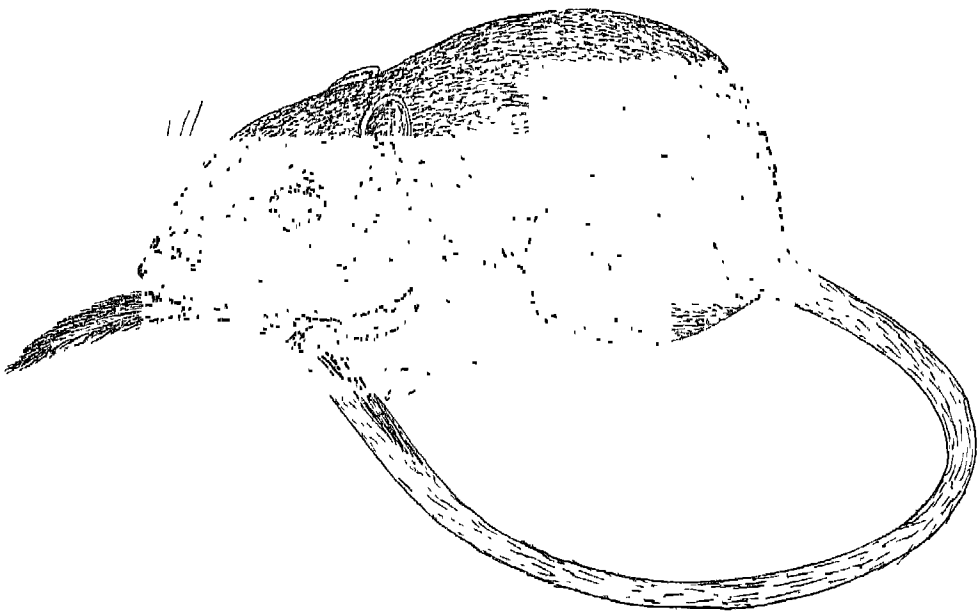

FIGURE 2.11 Kangaroo rat, a rodent of the desert.

(d) Some animals, especially the rodents of the deserts like the Kangaroo rat (Fig. 2.11), the jerboas (Fig. 2.12) and gerbiles can live on the water available in the air-dried seeds they eat. In fact jerboas are so much adapted to eating dry food that they will refuse water-rich food like carrots and cabbage. Among the larger animals, the camel is a remarkable desert mammal (Fig. 2.13). The camel abstains from drinking for long periods when grazing is ensured. It can drink even bitter salt water. The addax antelope (Fig. 2.14) and the oryx antelope of the desert do not drink at all but get water from their food.

Some peculiar desert animals

(a) The scorpions and allied animals (Fig. 2.15) form a conspicuous group of desert inhabitants. They hide under rocks and stones and feed on insects. Spiders with enormous jaws are known to occur in deserts. These may attack even

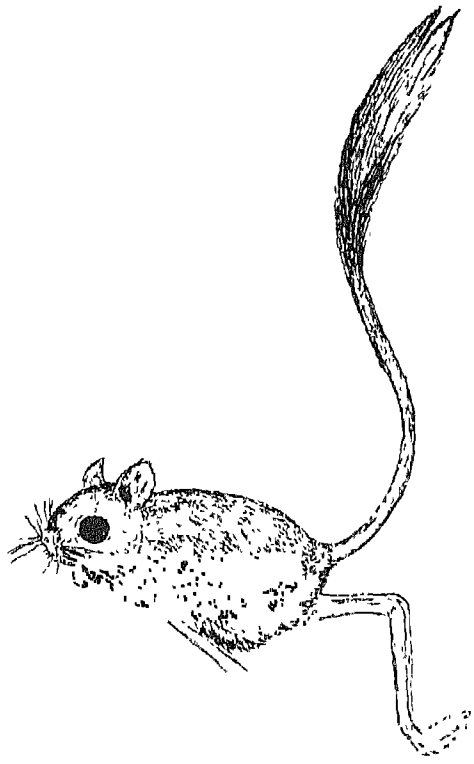

FIGURE 2.12 Jerboa, a rodent of the desert

small lizards, birds and mice. The trapdoor spider (Fig. 2.15) builds underground burrows which open to the surface through a hinged, tightly fitting, door. Scorpions and solifugae make deep pits in the desert soil and hide during the hot days.

(b) *The desert fox:* The desert fox *Fennicus* (Fig. 2.16) is well adapted for life in the desert. It lives on vegetables and animal matter, and feeds on insects, mice and lizards. It has a grey colour which serves as a camouflage because the rocks of the desert are of the same colour. The fennec fox also feeds on dates.

(c) *The reptiles* are the most interesting animals of the desert. Snakes of various types occur in the desert. They hide

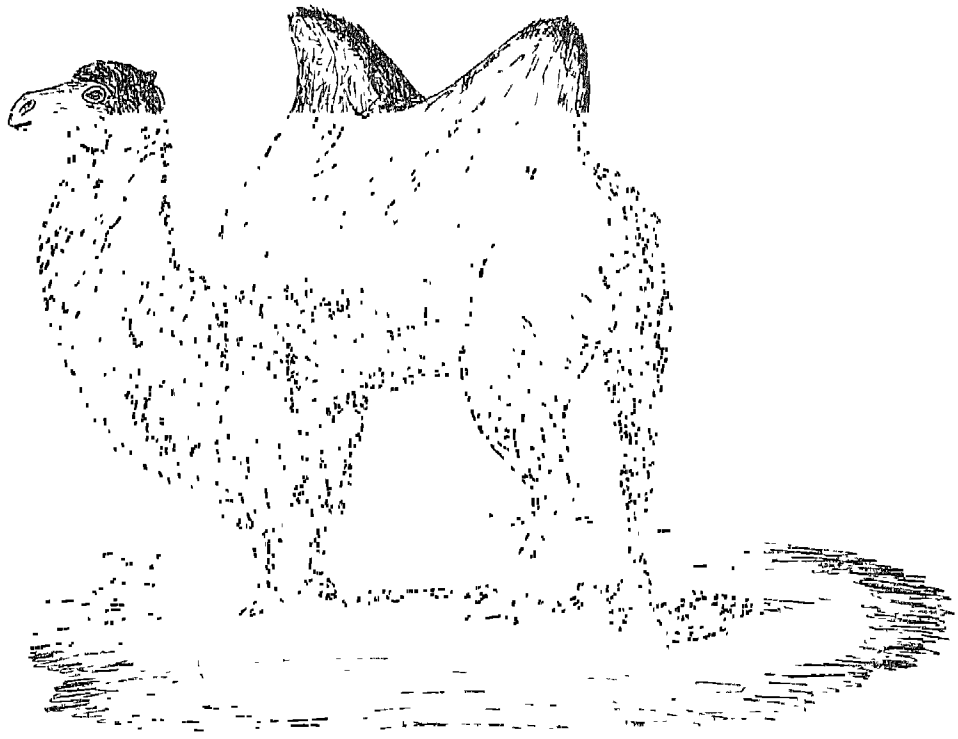

FIGURE 2.13 A Bactrian two-humped camel of Taklamakan desert in Central Asia.

under the rocks and in deep crevices (Fig. 2.17) and avoid the hot sun outside.

Some reptiles like the sluggish agamid lizard of the Australian desert (Fig. 2.18-A) have a skin of thick thorny layer which helps in preventing water loss from the body. These lizards (*Moloch hornudons*) feed on ants and lizards. The counterpart of these agamid lizards are called the *Iguanas* (Fig. 2.18-B) that inhabit the deserts of Western Hemisphere.

Reptiles of desert excrete very thick urine. This is a device for preventing water loss. Reptiles move about with remarkable speed. They have fringes along the toes which are helpful in running on sandy areas. Other reptiles show swimmimg movements in sand. When at rest these reptiles stand on four legs with the head held high. In this position they are very alert. During their motion the tail is held high

which helps them to keep balance. They can also burrow deep into the sand. To protect their nostrils from sand blasts desert snakes and lizards have special valves closing their nostrils.

(d) *Birds :* The distribution of birds in deserts mainly depends on the availability of water. Birds maintain constant body temperature. Therefore, they have to keep themselves cool, when the external temperature goes up. Birds such as sand grouse are active during the day time. Owls and nightjars, however, rest in trees and fissures in rocks throughout the day. The majority of desert birds are carnivores. Their food is rich in water content.

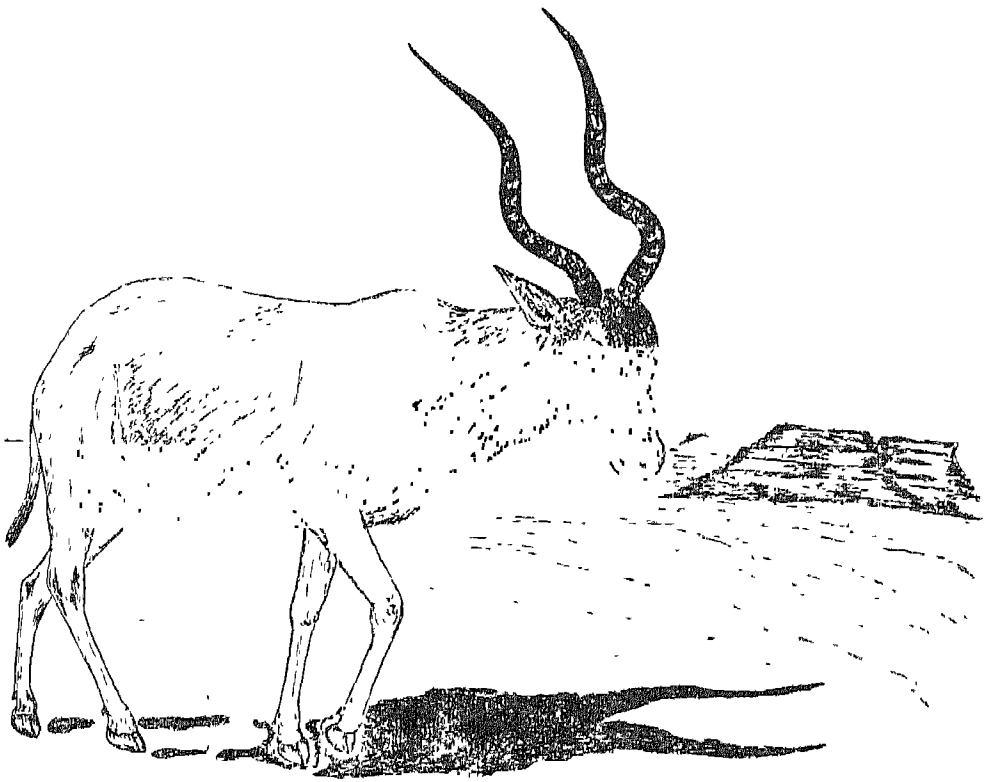

FIGURE 2.14 The Addax antelope, a beautiful animal of the desert. It lives deep in the centre of the North African desert. The lining of the stomach in this animal acts as a sponge and is permanently soaked in liquid It 'stores' water in its stomach.

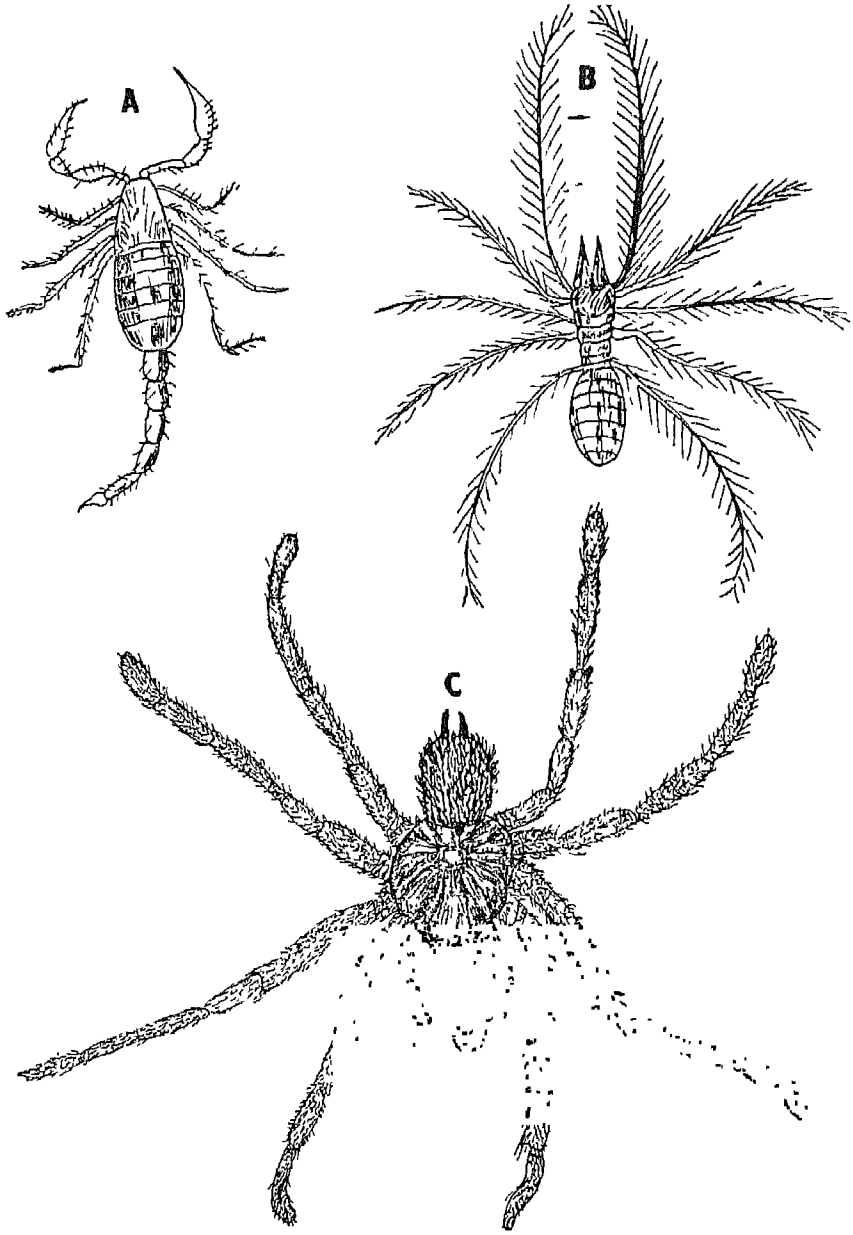

FIGURE 2.15 Some desert invertebrates.
(A) Scorpion (*Buthus occitanus*) (B) Solifugae (*Galeodes* sp.) (C) Trapdoor Spider.

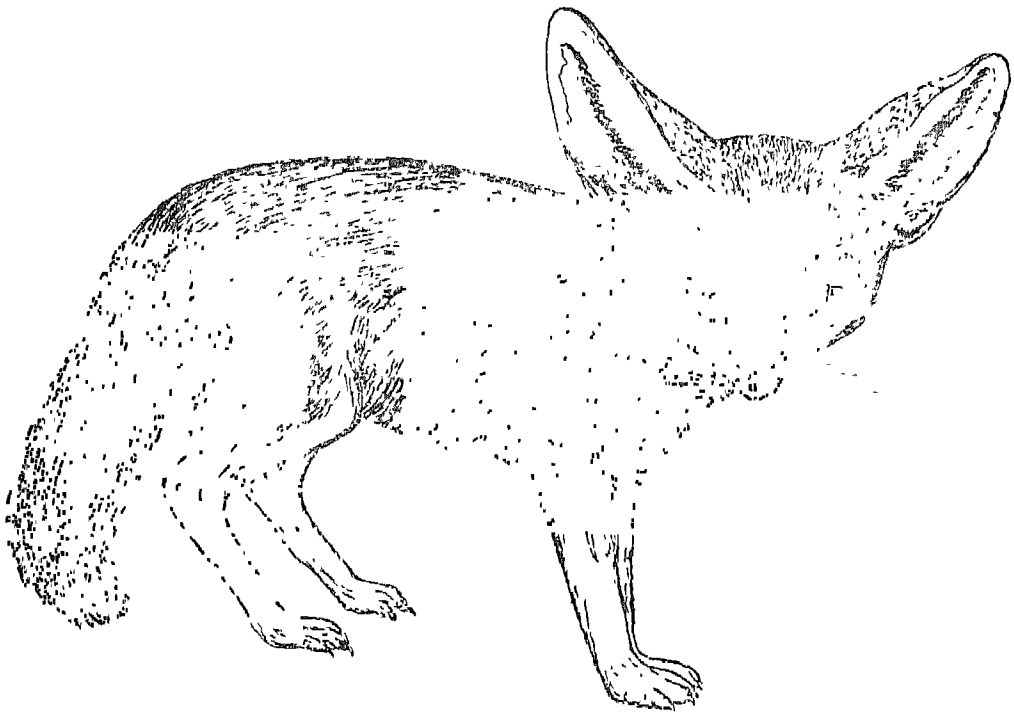

FIGURE 2.16 The Fennec fox A nocturnal desert animal extending from Northern Sahara to Asia.

The sand grouse is an interesting bird of the desert. The male bird soaks its breast feathers while drinking water. It flies back to the nest with this supply where the young ones squeeze out the soaked feathers between their beaks, and thus obtain water. During incubation the birds sit on the eggs and protect them from the heat of the hot sand. Some birds of the deserts, e.g., elf owl, make holes in the cacti and live in the space protected from the hot weather.

(e) *Large mammals :* Camels and donkeys can gulp down large quantities of water at a time. These large mammals can also tolerate a dry period but they drink large quantities of water whenever available. The thickness of the skin of camel reduces loss of water through evaporation to a minimum. The fine hair on the body of the camel acts as insulation to ward off excessive atmospheric heat.

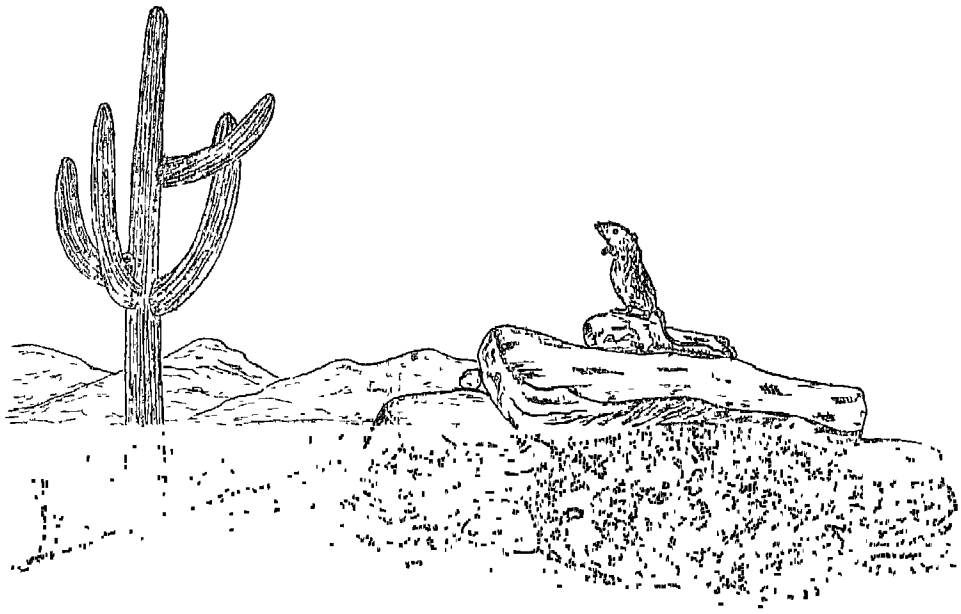

FIGURE 2.17 A desert snake hiding under a rock and waiting to attack a prey.

(f) *Rodents :* Rodents are the other small mammals of the desert. They require very little water for survival. Jerboas, gerbils and kangaroo rats are well known examples of desert rodents. They survive on dry food without water to drink. Their urine is extremely concentrated and their faeces dry. Little water evaporates from the lungs.

Kangaroo rat (Fig. 2.11) of the American desert and jerboas (Fig. 2.12) of Africa and Asia are nocturnal. They do not emerge from their burrows during the hot day-time. The moisture content of the air in the burrows is much higher than that of the atmosphere outside. This reduces the water loss from the lungs.

Man and Desert

Even though the world's deserts are caused by climatic and geographic factors, man has played a significant part in expanding them. For instance in ancient North Africa, patches of land were cleared of

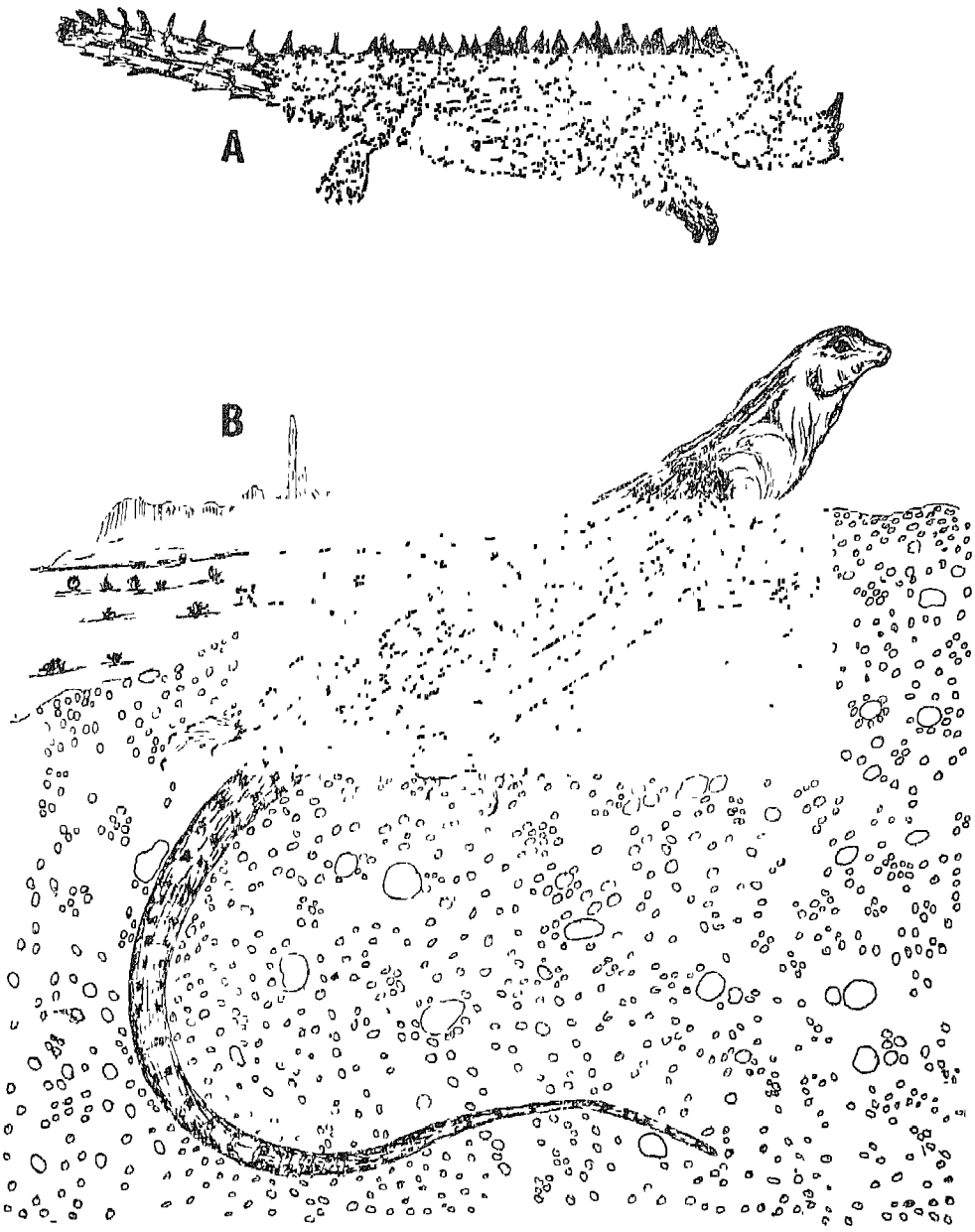

FIGURE 2.18 (A) Sluggish Agamid lizard (*Moloch horridens*) of the Australian desert. Its skin is thick and thorny and prevents water loss. (B) An Iguana, a desert lizard of the western hemisphere.

trees in order to cultivate food grains. The trees were cut down and burnt. The ashes supported a good crop. But once the minerals in the ash were depleted, the land was impoverished and abandoned. The cultivators moved to a different region and started the destructive process over again. Thus, the mistakes committed by the ancient people led to the expansion of the North African desert.

Men inhabiting the deserts have to lead a nomadic way of life for their survival. Nomadic tribes will find desert life very suited to them since rainfall in the desert is most erratic and uncertain. Most of the nomads are hardy people with great stamina and strength and with considerable skill in hunting. They keep alert all the time and live in small family groups of larger camps. The African bushmen and the Australian aboriginals are well known examples of desert tribes.

CHAPTER III

FOREST LIFE

A forest is an ecosystem in which the vegetation is dominated by trees. Trees can thrive in places where there is a moderate rainfall throughout the year. Such a condition occurs in many regions of the world situated at different latitudes and longitudes. Except for the amount of rainfall and its distribution during the year, these regions may differ in other climatic factors such as temperature and daylength, and in soil conditions. As a consequence of these differences, various kinds of forests are produced.

The influence of these factors together with the location and position of an area on the globe, i.e., latitude, altitude and the relative distance of the area from the tropics towards the poles, govern the nature of the forests.

One can more or less recognize five major forest types which are not however strictly demarcated by clear cut boundaries and are not restricted to one continent or the other. These are (1) the tropical rain forests, (2) tropical deciduous forests, (3) tropical scurb forests or jungles, (4) middle latitude deciduous forests and (5) the middle latitude coniferous forests.

In India, the middle latitude forests occur only in the high altitudes of the Himalaya and other mountains, where a temperate climate prevails. Tropical forests of India are mainly of three categories.

Tropical Rain Forest

A. Location and climate

The tropical rain forest contains the most luxuriant vegetation of the world. It occurs close to or within the limits of the Tropic of

Cancer and the Tropic of Capricorn where rainfall is plentiful and uniformly distributed throughout the year and where the temperatures are high and relatively uniform. The most extensive stands of this

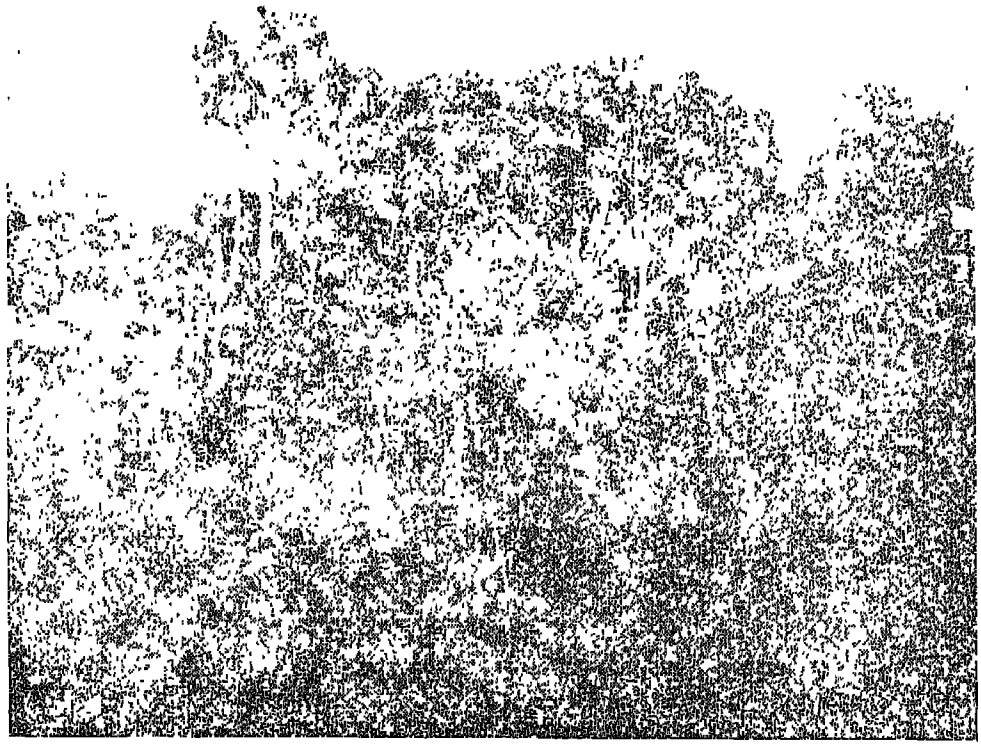

FIGURE 3.1 Wet evergreen tropical forest of Assam.

forest are located in the western ghats of Southern India and in Assam (Fig. 3.1), Malaysia, East Indies, Central America and Central Africa.

Rainfall is the most important factor that influences the extent of the tropical rain forest. The proper development of a typical rain forest requires at least 200 cm of rainfall more or less uniformly distributed during the year. However, a rainfall of 150 cm per year might allow development of a less luxuriant rain forest if there is no dry spell exceeding two months.

B. Stratification

The dominant vegetation of tropical rain forest consists of tall, evergreen, broadleaf trees. The crowns of all the trees are not of the same height and hence form various levels or strata (Fig. 3.2). The

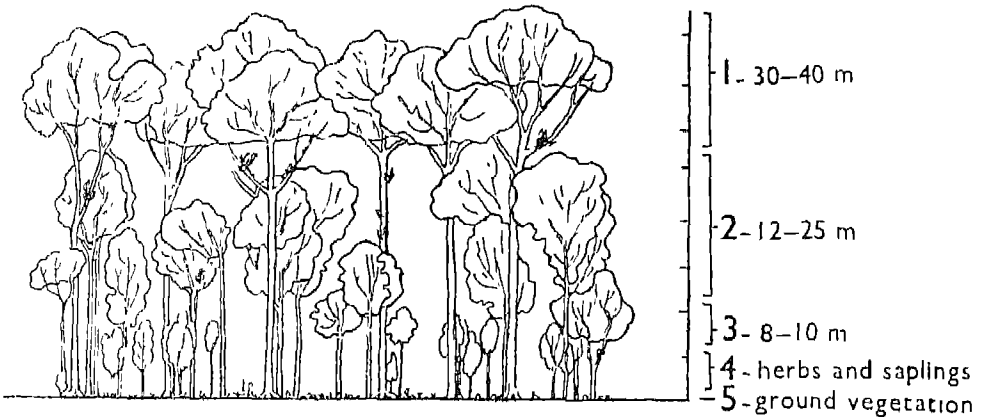

FIGURE 3.2 Stratification in a rain forest.

highest stratum may extend from 30 to 40 metres but a few trees may reach a height of 50 metres or more. The second stratum extends from 15 to 25 metres and the third from 8 to 10 metres. Below the third stratum is a layer of shrubs and sapplings and finally there is a layer of herbaceous plants along with liverworts, mosses, ferns, etc., on the forest floor. However, these strata may not always be present in a strict sequence.

The dominant trees may belong to various species. Usually there may be 50 to 100 species having trunks of over 10 cm in diameter. Some of the tallest and most important trees of the rain forests of the Western Ghats are *Dipterocarpus indicus*, *Vateria indica*, *Palaquium ellipticum* and *Cedrela toona*. In some rain forests, however, a single tree species may dominate.

The trunks of many tall trees have plank-like buttresses which provide sufficient support to the trunk (Fig. 3.3). A notable tree type of certain forests is what is known as the strangler. A strangler begins life as an epiphyte but after many years becomes self-supporting (Fig. 3.4). The seeds of stranglers like *Ficus*, *Schefflera*, and *Clusia*

FIGURE 3.3 Plank buttress of a rain forest tree.

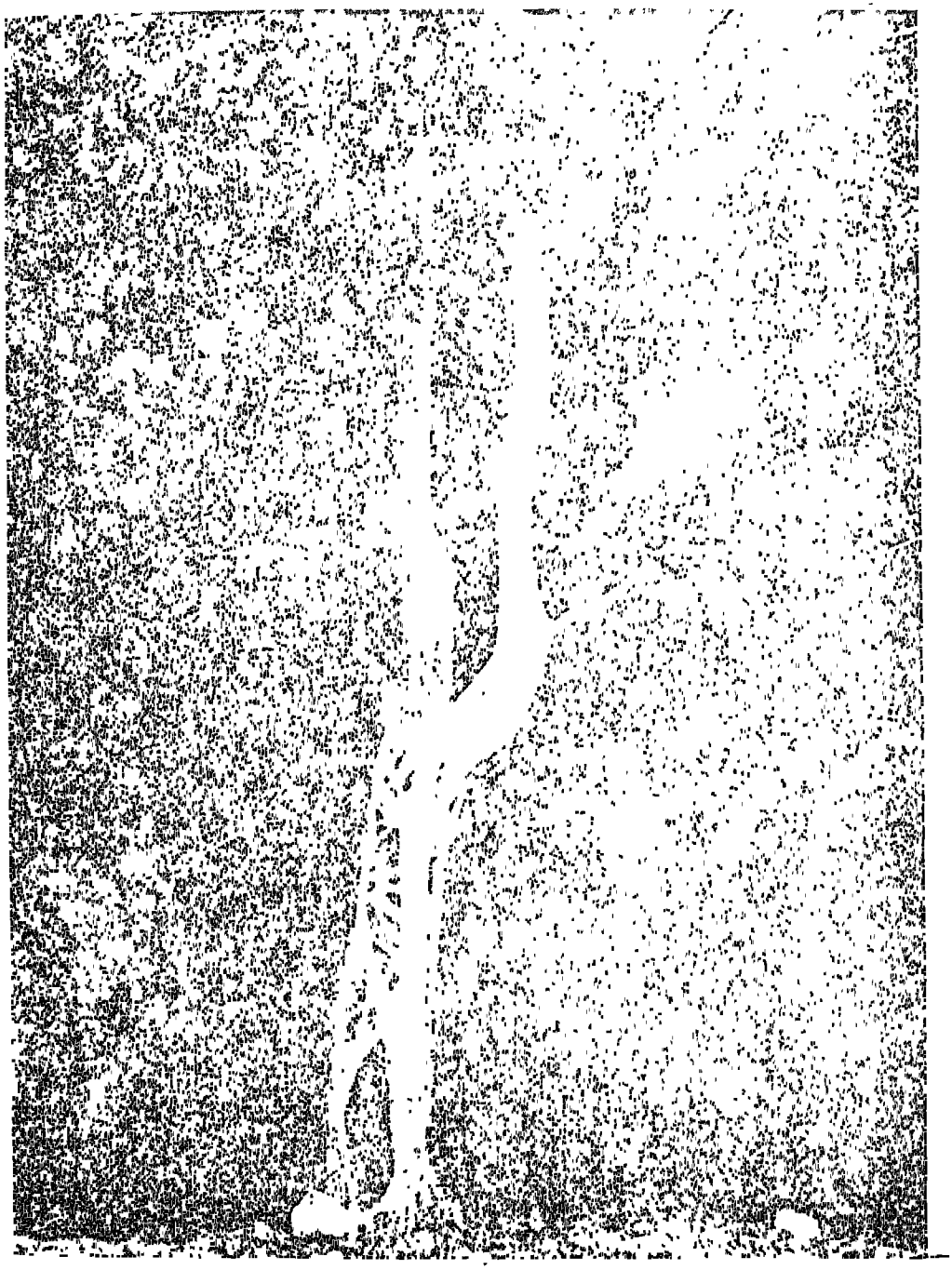

FIGURE 3.4 A strangler and its host in a forest.

germinate on the trunk of other trees and live as epiphytes for some time. Usually they produce two kinds of roots. One kind acts as holdfasts for the plant, maintaining its position on the host tree and the other grows down to the soil. The latter after becoming rooted in the soil, wrap around the trunk of the supporting trees and gradually strangle it. The host tree finally dies leaving the strangler which has a trunk formed of a number of fused roots that are firmly rooted in the soil.

Lianas or woody vines are another type of plants characteristic of the rain forests. These plants often climb to the top stratum of the forest. Some of these twine around a tree, and may subsequently even strangle it while others climb by means of tendrils. Some send aerial roots straight down from upper branches. The lianas may reach a diameter of 15 to 45 cm and a length of more than 100 metres.

C. The undergrowth

The layers of shrubs and herbs are not usually dense. The forest interior looks like a large hall wherein the trunks of the tall unbranched trees form the pillars that support the thick canopy above. Consequently, very little light reaches the forest floor. This drastic reduction in sunlight does not allow many shrubs and herbs to establish themselves as forest undergrowth and this in turn accounts for the emptiness of the forest interior. Often, patches of bare ground may be exposed where the forest has been cut or destroyed. In these restricted areas where sunlight is able to penetrate, a tangled mass of vegetation consisting of dense herbs, shrubs and creepers develops.

D. The fauna of tropical rain forest

The number of animal species is also large in the rain forest. It has been estimated that about 85 per cent of the bird species of the world inhabit these regions. In the rain forests of our country, *Dumetia hyperythra* (babbler), *Nectarina zeylanica* (sunbird), etc., (Fig. 3.5) are common.

The warm humid air of the tropical rain forest is an ideal environment for tree frogs, many of which are totally arboreal. They lay their eggs in clusters on the branches of trees overhanging the banks of a river

or lake. Upon hatching, the larvae drop into the water and complete their development. Among the reptiles, chameleons with grasping feet and prehensile tails are common. Large snakes such as the pythons and boas are present although not numerous.

FIGURE 3.5 Some birds of tropical rain forest.
1. Slatyheaded scimitar babbler. 2. The Crested serpent eagle (*Spilornis cheela*). 3. Yellowbacked sunbird (*Nectarina zeylancia*). 4. The Shama (*Copsychus malabaricus*). 5. The Grey jungle fowl (*Gallus sonneratii*).

One may not encounter many mammals in the day-time because, most of them, with the exception of monkeys, are active only after sunset. Bats, leopards and many rodents are nocturnal in habit. Most of the ground dwelling mammals such as the goat antelope and barking deer are small in size. The notable mammals of the South Indian forests are Nilgiri Tahr (*Hemitragus hylocrius*), the lion-tailed macaque, the Nilgiri brown mongoose, the stripe-necked mongoose, the Malabar civet, the elephant (*Elephas maximus*) and the gaur.

E. Soil and litter life

Despite the abundant trees and lianas which provide home for animals, a majority of the animals live on the forest floor. This is perhaps due to the fact that the forest floor provides a very stable environment

Of all the animals, ants are probably most numerous and conspicuous. Their numbers may vary with the season, becoming more abundant during the wet months. Animals in the soil and litter include ants, earthworms, leeches, mites, spiders, snails, millipedes, beetles, termites and insect larvae. Ants, mites, spiders, leaf hoppers, beetles, wasps, bees and butterflies are abundant on the vegetation of the lower strata.

The rain forest floor is devoid of a thick litter. Leaves and other organic debris that constantly fall down to the floor from the upper strata undergo rapid decomposition. The large population of insects, bacteria and fungi quickly dispose of or decompose the falling debris so that in a matter of few weeks even entire trees or branches that have fallen disappear.

F. Some special features

Some interesting associations of plants and animals occur in the rain forest. Many ants feed on the exudates of various kinds of plant bugs and leaf hoppers. A wide variety of animals live in the water trapped in the leaf-bases of bromeliads and other plants. These include worms, snails, crustaceans, leeches, freshwater crabs, etc. An interesting situation is seen in one species of tree frog which lays successive batches of eggs in the water accumulated by the plants. The progeny hatched out from the earliest eggs feed on the eggs laid later.

Epiphytes which grow on trees and obtain all their moisture from the air are abundant in the rain forest (Fig. 3.6). The most common

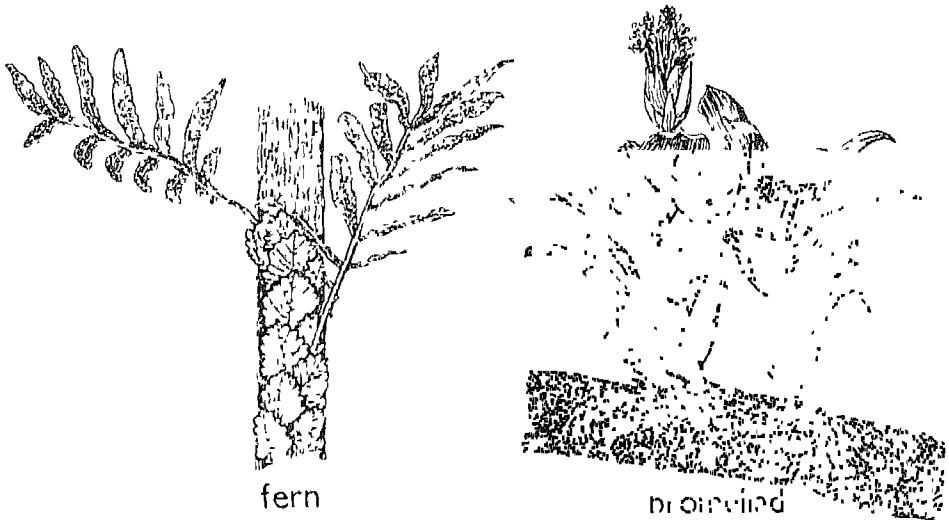

FIGURE 3.6 Two epiphytes of tropical rain forest.

ones belong to the pineapple, orchid, milk weed and fern families. Many species of algae, lichens, mosses and liverworts, also grow as epiphytes on the barks of trees. A majority of the epiphytes are adapted to survive on low amounts of water but a few such as the tank bromeliads store water in their leaf bases.

Tropical Deciduous Forest

A. Climate and location

The tropical deciduous forest occurs in tropical regions where the rainfall is about 100 to 150 cm per year with a dry season of more than a couple of months. Most of the trees in these forests minimize the loss of water during the dry season by shedding their leaves (Fig. 3.9). Such trees are described as deciduous and the forest in which they predominate is known as the deciduous forest.

A deciduous forest is spoken of as moist deciduous (Figs. 3.7, 3.8) if situated in a place where a humid climate prevails for most part of the

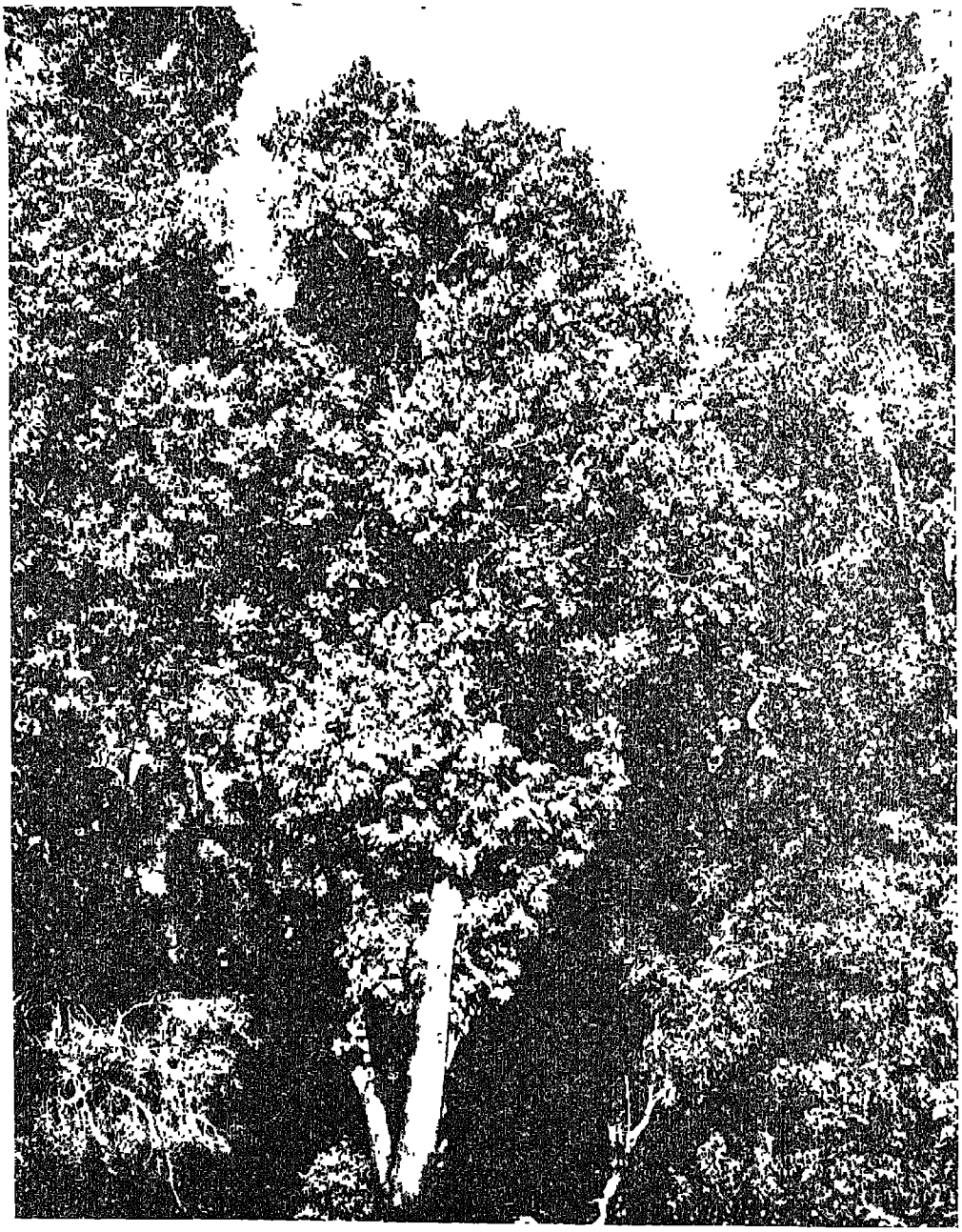

FIGURE 3.7 An aspect of the vegetation of a moist deciduous forest.

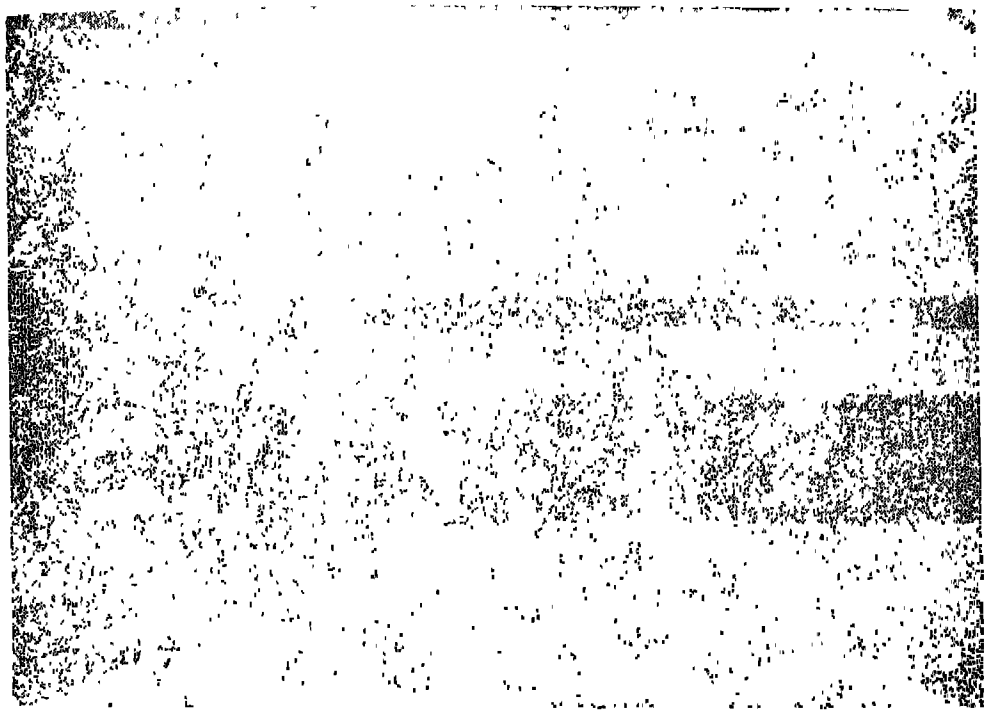

FIGURE 3.8 Another aspect of the vegetation of a moist deciduous forest.

year, and dry deciduous (Fig. 3.9) when it occurs in a place where the climate is dry for a major part of the year. Deciduous forests are found throughout Peninsular India excepting the arid central regions.

B. Stratification

In a deciduous forest the canopy is not so deep and dense as in a rain forest and the number of strata is less (Fig. 3.10). The upper stratum is formed by the crowns of trees of different heights. Since the canopy is not deep and dense, much light penetrates all the way to the forest floor which, as a result, becomes covered by a dense mass of undergrowth.

C. Vegetation

The important trees that form the top stratum in the moist deciduous forests in India are *Pterocarpus marsupium*, *Terminalia*

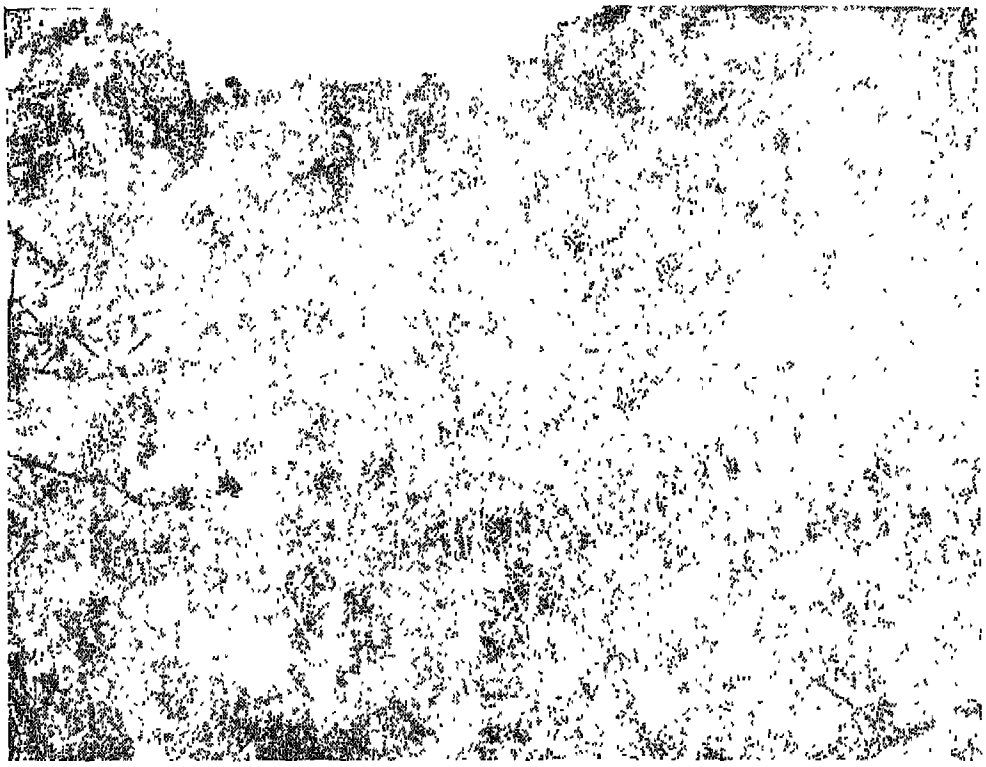

FIGURE 3 9 Dry deciduous forest at leaf fall.

bellerica, *Dalbergia latifolia*, *Dillenia pentagyna* and *Madhuca indica*. Besides these, *Tectona grandis* (teak) occurs in the southern and central India and *Shorea robusta* (sal) in U.P., Orissa, Bihar, West Bengal and Assam.

The herb and shrub vegetation at the ground level include the following plants ; *Murraya exotica*, *Atlantia monophylla*, *Canthium glabrum* and the small bamboos *Oxytenanthera nigrociliata* and *Bambusa schizostachyoides*.

The trees of the dry deciduous forests are teak, sal, *Pterocarpus santalinus* (red sanders), *Hardwickia binata*, *Santalum album* (sandalwood), *Boswellia serrata*, etc.

D. Soil litter

During the dry seasons, the amount of soil litter increases by the

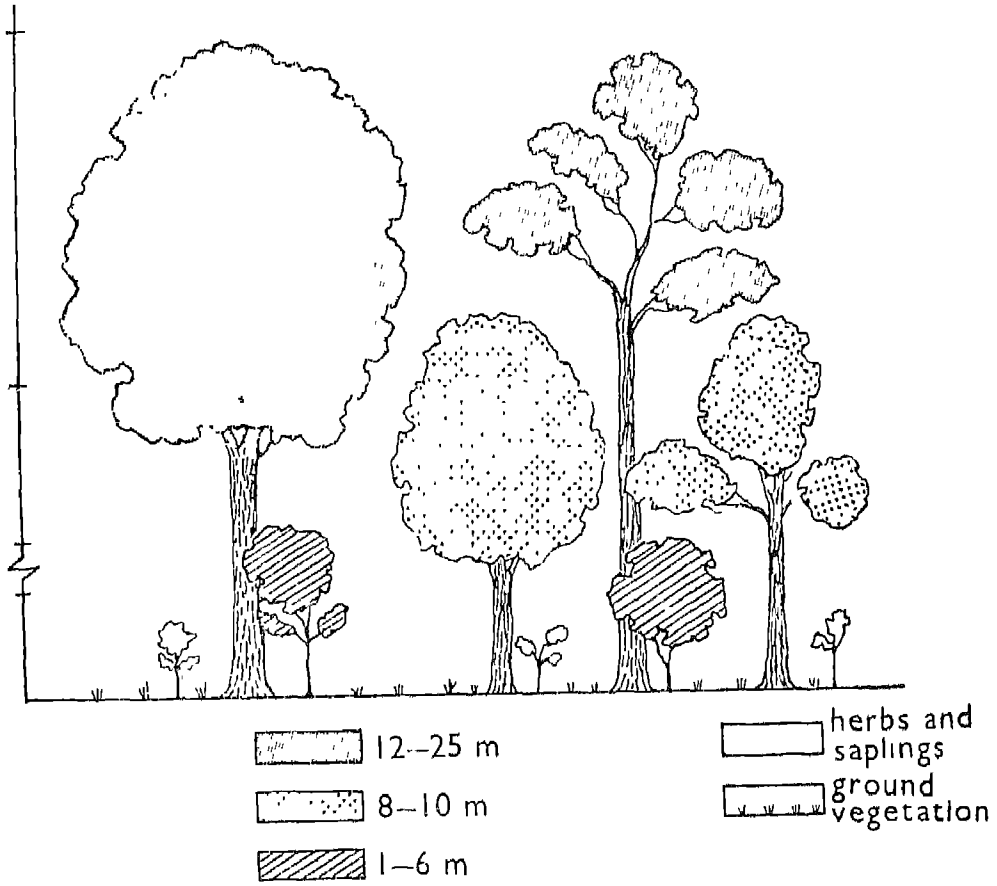

FIGURE 3.10 Stratification in a moist deciduous forest.

accumulation of fallen leaves (Fig. 3.11). The falling leaves may be those that have dried on the trees or green ones with a good amount of moisture. The fallen leaves provide shade and cover to the innumerable animals known as " litter organisms " such as insects, worms, millipedes, etc. In the dry deciduous forests the litter largely remains unconsumed until the advent of the wet season. Once the wet season commences, the litter becomes sufficiently moistened and saprophytic fungi and litter organisms begin to consume it. Thus the amount of litter becomes quickly reduced and remains rather thin until the advent of the next dry season.

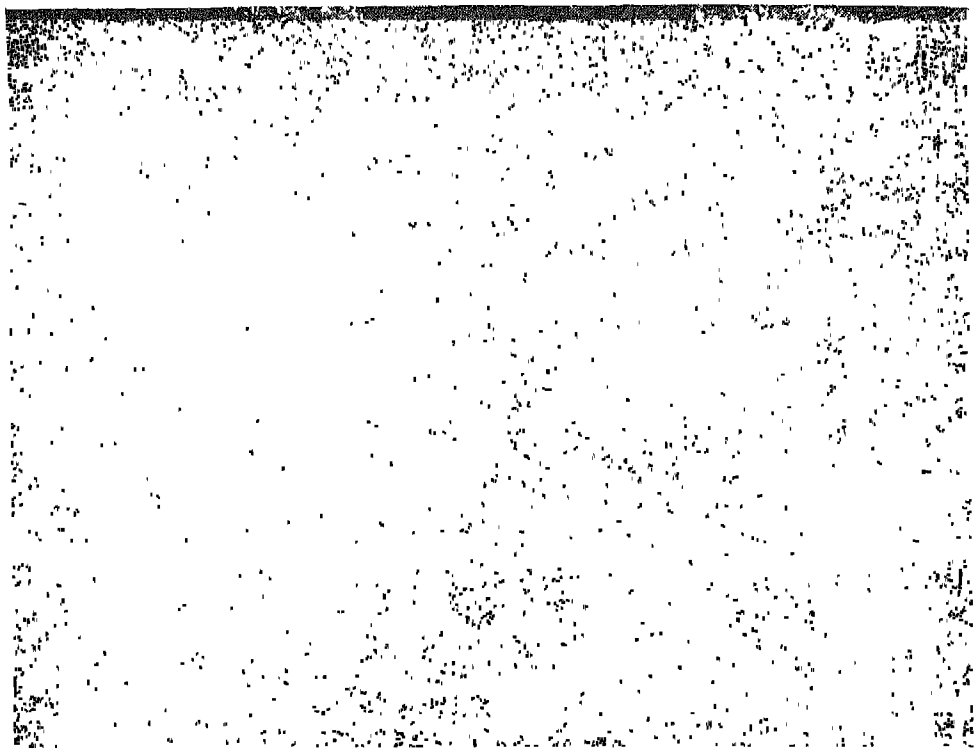

FIGURE 3.11 Soil litter of a forest during summer.

E. Animals

Most of the animals found in the tropical rain forests are found in the tropical deciduous forests also but in lesser numbers. The familiar animals of the deciduous forests of the Indian peninsula are *Axis axis* (spotted deer), *Baselaphus tragocamelus* (nilgai—Fig. 3.12), *Antelope cervivapra* (black buck), *Tetraceros quadricornis* (four horned antelope) and the sloth bear which are found nowhere else in the world. Some common birds are *Terpsiphone paradisi* (paradise flycatcher), *Pycnonotus jocosus* (Red whiskered bulbul), (Fig. 3.13), etc. Many animals of the tropical deciduous forests go into a state of inactivity during the dry season. This is known as aestivation. The animals that are most likely to aestivate are insects and cold-blooded animals.

FIGURE 3.12 Nilgai, a deciduous forest animal.

Tropical Scrub Forest or Jungle

A. Climate and location

The tropical scrub forest occurs in semi-arid regions of the tropics with a rainfall of about 25 to 50 cm per year. In India, scrub forests occur in the plains of Deccan and in the dry regions of the Indo-Gangetic plain.

B. Vegetation

The vegetation of the scrub jungle comprises widely separated short trees, 3 to 10 metres high and stunted herbs and shrubs growing

FIGURE 3.13 Some birds of tropical deciduous forest
1. Paradise Flycatcher (*Terpsiphone paradisi*) 2 Rockettailed Drongo (*Dicrurus paradiseus*) 3. Red-whiskered Bulbul (*Pycnonotus jocosus*) 4. Collared Scope Owl (*Otus bakkamoena*) 5. Red Jungle Fowl (*Gallus gallus*)

either sparsely or in dense clumps (Figs. 3.14, 3.15). The ground between the clumps is mostly bare but may have a thin growth of grass

FIGURE 3.14 A bushy scrub forest without trees.

at places. A characteristic feature of many herbs, shrubs and trees in the forest is the possession of spines and prickles of various kinds which make it difficult for one to pass through them. Because of the thorny nature, a scrub is also called a thorn forest.

Typical thorn trees of Indian scrub forests are *Acacia* spp. and *Prosopis spicigera*. Thorny shrubs are *Euphorbia*, *Zizyphus*, *Dichrostachys* and others.

The thorns are often modification of leaves or branches and hence a means of reducing the surface area to cut down loss of water through transpiration. The plants usually have small leaves provided with hair or a coating of wax that prevents water loss. Many are leafless except during the rainy season. Some have underground parts where water is stored, as an adequate safeguard against drought.

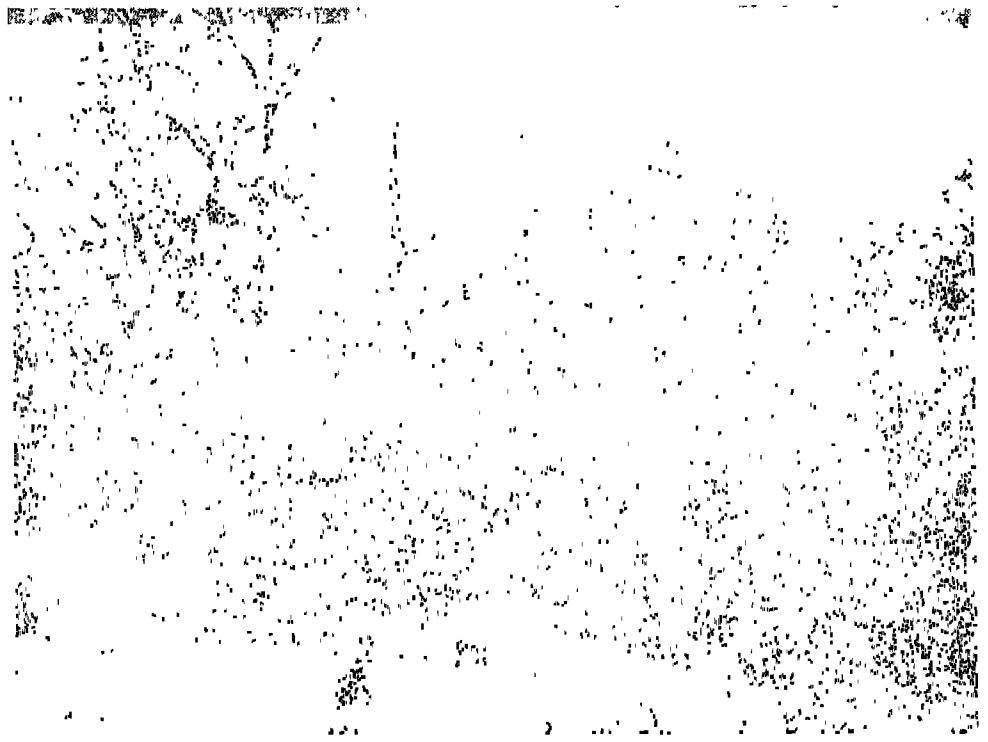

FIGURE 3.15 Scrub forest with small trees.

C. *Animals*

The animals that inhabit these forests are fewer than those in the rain forests and deciduous forests. *Prinia socialis* (Ashy wren warbler), *Francolinus pondicerianus* (Grey partridge), etc., are some of the common birds (Fig. 3.16). Rodents, lizards, snakes, hyaena (Fig. 3.17), rabbits and foxes are also common. Scorpions, spiders and insects live in the shelter provided by stone crevices and clumps of vegetation. A considerable amount of litter accumulates on the ground only during summer. This is slow to be consumed, because the high temperature and low humidity do not favour the existence of saprophytic fungi and litter eating animals. The amount of humus in the soil is, therefore, small.

FIGURE 3.16 Some birds of scrub forest
1. Crow pheasant or coucal (*Centropus sinensis*). 2. Ashy wren warbler (*Prinia socialis*). 3. Grey partridge (*Francolinus pondicerianus*) 4. Goldenbeaked woodpecker (*Dinopium benghalense*). 5. Jungle babbler (*Turdoides striatus*).

General Features of Forests

Since trees are dominant and smaller plants play a sub-dominant or minor role in a forest, the characteristic overall appearance and external features of a forest are largely brought about by the kind of trees that grow in it. Besides being responsible for the characteristic external features of forests, trees also control the kinds of smaller plants. The distribution of the animal inhabitants of a forest is also influenced to a great extent by the trees. Thus, a forest may be described as an ecosystem which is controlled by the dominant tree vegetation.

Among trees some belong to the naked seed plants grouped under the "conifers". Most conifers grow in a cold climate and do not normally thrive in hot tropical climates. We have a small but

FIGURE 3.17 Hyaena, a scrub forest animal.

important belt of conifers in the Western Himalaya (Fig. 3.18). The most common coniferous trees are *Pinus roxburghii* (chir pine), *P. wallichianus* (blue pine), *Cedrus deodara* (Himalayan cedar), *Picea morinda* (Himalayan spruce) and *Abies pendrow* (Himalayan fir). But a majority of forests in our country, as also in the other tropical areas of the world are composed of the closed seed plants, i.e., the angiosperms.

Besides domination by trees, another feature common to all forests is stratification of the vegetation. The foliage of the tallest trees constitutes the canopy or topmost stratum and the shorter trees form the next one or two strata. The shrubs and herbs form the lower strata and finally the ground vegetation forms the ground stratum. The

FIGURE 3.18 Coniferous forest of North Western Himalayas.

stratification of the flora also influences the distribution of the fauna of a forest to a large extent. Particular kinds of animals may dominate particular strata but there may be others which are equally abundant in almost all strata. For example arboreal animals like monkeys and birds abound in the top strata, whereas animals like millipedes, centipedes, leeches, etc., are numerous in the soil litter. Many insects are however abundant in all the strata.

The lower strata of a forest are primarily controlled by the top stratum. In case the top stratum consists of dense foliage and spreads uniformly, much of the sun's rays cannot penetrate below. The whole space underneath such a top stratum will be densely shaded, and will have scanty vegetation. Only in places where there are gaps in the top stratum light can reach the ground and in such places the lower strata will have dense vegetation.

While it is true that the climate of a particular region determines the kind of dominant trees (gymnosperms or angiosperms) that would grow in a forest, the particular species that occur there are determined by other factors, the chief of which are the soil factors. Soils are derived from parent materials of different chemical composition in different regions. Although vegetation brings about certain changes in soil composition over the years, the fundamental soil differences persist and support different species of plants. Thus, due to soil differences, the same kind of forest occurring in different geographical regions may have different species of plants growing in it. Also in the same region, if the forest spreads over vast areas, the soil conditions may not be uniform throughout and hence groups of different species of plants occur in different areas of the forest.

Utility of Forest to Man

Forests have ever been of prime importance in the life of primitive man and his civilized descendants. Forests provided shelter and refuge to early man and wild animals. Forests have profoundly influenced civilisations like the African, Eskimo, Early Egyptian, Greek and Roman. Forests and forest products have been so intimately associated with early man that almost everything came from forests, i.e., food, drugs, clothing, housing, fire, tools, weapons and other equipments.

Wood obtained from forest has been a prime and universal raw material since ages. Its utility started during the old stone age as a digging tool in search of food and for burning. Even today millions of people use wood as fuel for cooking food and warming themselves in winter. In India, 92 % of the total harvested wood is used for this purpose. A vast amount of food is used as timber for buildings, bridges, railway sleepers, fencing, furniture and in numerous other ways. *Tectona grandis* (teak)—a timber of national and world importance is highly valued for building construction and also for the making of drawing room furniture. *Shorea robusta* (Sal), *Terminalia tomentosa* (laureal) and *Dipterocarpus pilosus* (gurjan) are timbers of regional and national importance, while *Anogeissus pendula* is of local importance in places where it grows. Timbers like *Dalbergia latifolia*, *Palaquium ellipticum* and *Pterocarpus dalbergioides* have a wide export market.

Besides these diverse uses of wood as fuel and building material, mention may be made of some of the other products based on forest products such as packing cases (*Abies pindrow*, *Bombax ceiba*, *Tetrameles nudiflora*), cabinet ware, boat building, textile and auxiliaries *Adina cordifolia*, *Boswellia serrata*), sport goods (*Morus alba*, *Fraxinus* spp., *Salix alba*, *S. fragilis*, *Celtis australis*), pencils (*Juniperus virginiana*, *Cupressus torulosa*, *Kydia calycina*), battery separators (*Abies pendrow*, *Picea morinda*, *Michelia champaca*), matches (*Sideroxylon longepetiolatum*, *Endospermum malaccense*, *Ailanthus* spp. *Canarium euphyllum*, *Salmalia malabarica*), plywood, building boards, (*Dipterocarpus* spp., *Canarium* spp., *Calophyllum* sp., *Cedrela toona*), paper and pulp (Bamboo, *Boswellia serrata*, *Pinus* spp., *Eucalyptus* spp.), etc.

Another very ancient but still important use of forests lies in the production of minor forest products such as tanning material (*Ceriops* spp., *Cassia fistula*, *Cassia auriculata*, *Terminalia chebula*), katha and catechu industry (*Acacia catechu*), essential oils, viz., sandalwood oil (*Santalum album*), lemon grass oil (*Cymbopogon citratus*) and vetiver oil (*Vetiveria zizanoides*), rosin and turpentine (*Pinus roxburghii*), resins like dammar (*Shorea* sp.), gums, rubber (*Hevea braziliensis*), dyewoods, cork (*Quercus suber*), and medicinal plants such as quinine (*Cinchona* spp.) and Serpentina (*Rauvolfia serpentina*), etc.

Besides providing raw materials useful to man in various ways,

forests prevent soil erosion especially on hill and mountain slopes by holding the soil, and also offer natural barriers against strong winds. By moderating the flow of rain water from the land, they help not only to prevent the recurring cycle of flood and drought encountered in many treeless areas, but also conserve the water supply for water power, agriculture and drinking purposes. Forests ameliorate the climate and turn the mountains and non-arable lands into beautiful landscapes which offer a satisfying aesthetic experience to the human mind.

CHAPTER IV

WEB OF LIFE

You have learnt that plants and animals can live in varied habitats if conditions are favourable for obtaining the needs of life such as food, shelter and protection. In order to perpetuate, they should also be able to reproduce. To realize these, the organisms are very much interdependent. Thus the life of a community represents a web of relationships among its members. We shall study, in this lesson, the food and reproductive relationships of organisms.

Food Relations

(a) *Food chains and food webs*

We can get an idea of the food relationships between organisms if we examine the sources of food of some familiar plants and animals. For example, rice forms a source of food for mice. The mice in turn are food for the mongoose. These food relationships can be diagrammatically represented as follows :

Rice... ....Mice.. . . . .Mongoose

In terms of food relations, this example represents a simple food chain. But we know that this situation is rather only one of several possible course of events. Food relations in any given community are more complex, as organisms of different food habits live together. For example, starting with rice, we may consider that it is eaten not only by mice but also by sparrows which in turn form the food of eagles ; likewise some mice may be eaten by mongoose, whereas some are eaten by cats, snake or eagles. Cats being omnivores may also feed on cooked

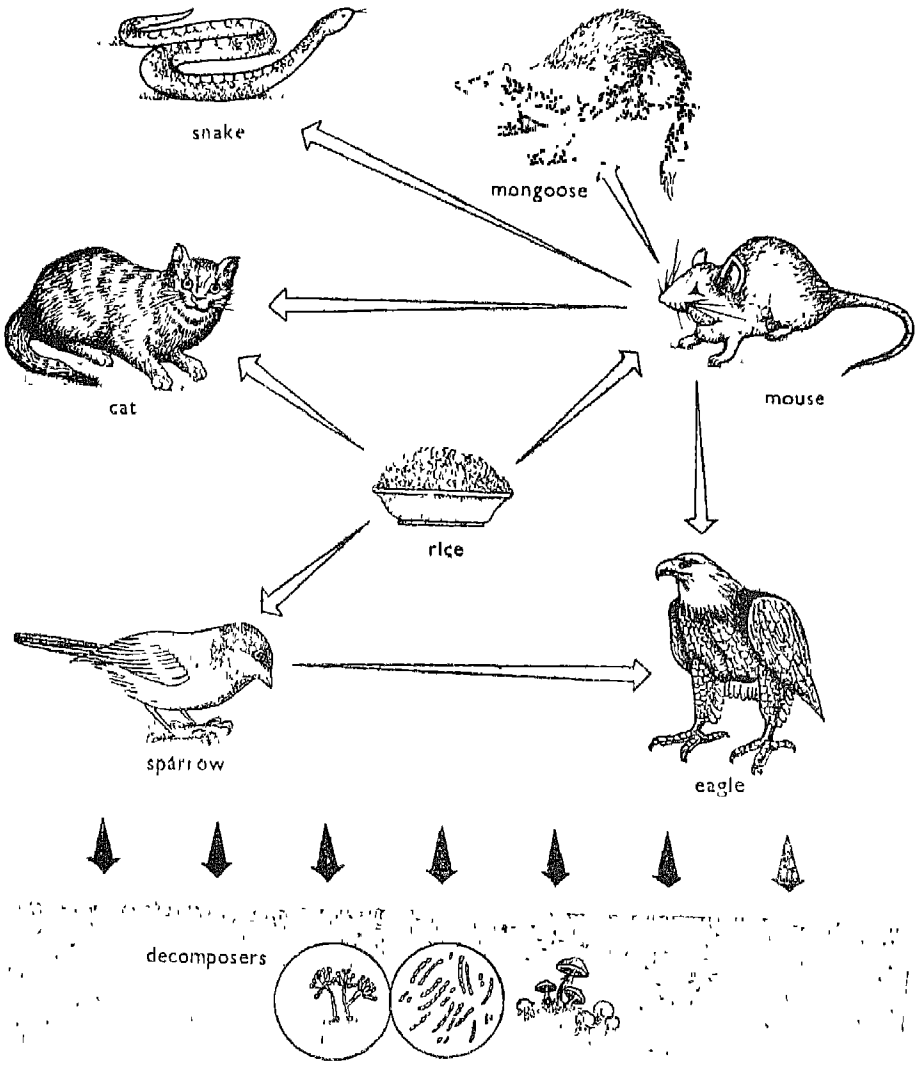

FIGURE 4.1 Web of life.

rice. All these animals when dead, from the source of food for decomposers such as saprophytic fungi and bacteria. The decomposers bring about the disintegration of organic matter into simple substances which again become useful to the green plants. The food relationships just described are shown in Fig. 4.1. From the figure it is clear that organisms of a community may not be linked together in a direct chain ; but may be interlinked in many directions. The relationships described are thus

quite complex and form food web. The food relationships we have considered are not something final. One can elaborate them in many other ways. Indeed it would be difficult to picture the food relationships of a community as food chains change from time to time and from place to place in a given habitat.

Practical

Based on your own knowledge, construct a food web of a community of organisms of a cultivated field. The community may include the following organisms :

1. Grasshoppers
2. Earthworm
3. Lizard
4. Sparrow
5. Crow
6. Parrot
7. Rat
8. Mongoose
9. Eagle
10. Cow
11. Bull
12. Snake
13. Maize
14. Man

(b) *Producers and consumers*

Green plants, as you know, can synthesize food from simple raw materials. Hence, in every community, they form the primary source of food and are known as the producers, whereas the others represent consumers.

From the view point of food, the producers occupy the first level in a community. Among the consumers, the herbivores (the primary consumers) occupy the second level as they directly feed on plants whereas the carnivores (secondary consumers), the third level (Fig. 4.2).

In any community, omnivores such as sparrows, crows, house rats or dogs occupy variable food levels, for they can feed on plants, animals and their products. Therefore, they have a distinct advantage over other consumers. Thus they are better adapted in regard to their food requirements than herbivores or carnivores.

Of all the consumer organisms, the food position of saprophytes is unique, for they live on the dead remains of organisms—producers or consumers including their own kind. Thus they are directly related to every category of organisms by their food habit.

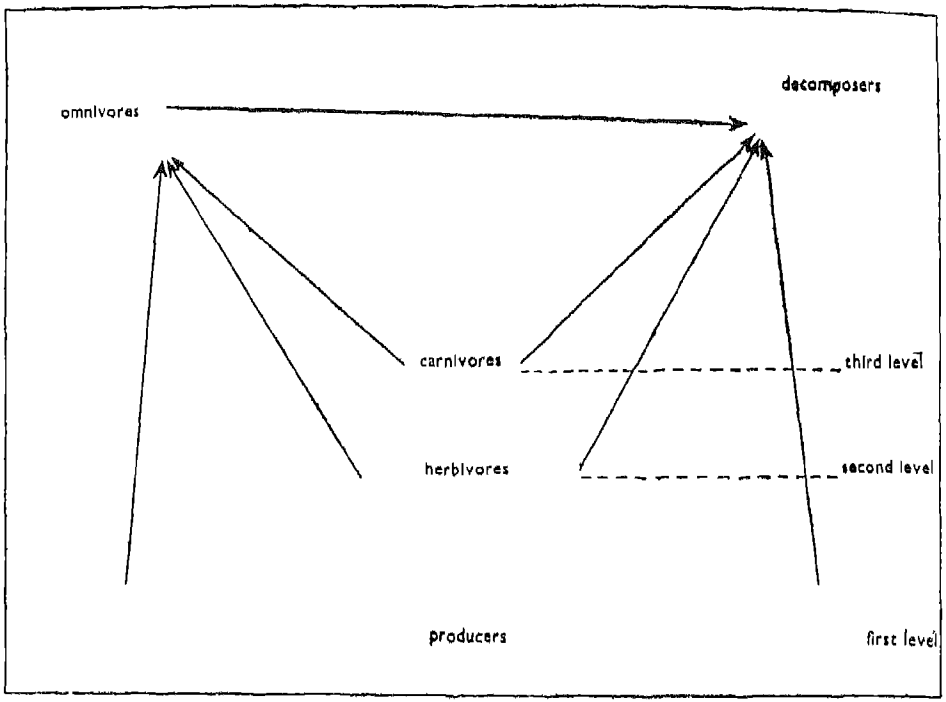

FIGURE 4.2 Food levels and food relationships.
Producers as first food level.
Herbivores as the second food level.
Carnivores as the third food level.

Practical

1. Classify the organisms of the food web that you have constructed in the previous practical, into their respective food level categories on the basis of their food habits.
2. From which of the food levels can we derive maximum food material ?

(i) *Food webs in freshwater and the sea*

A variety of plants and animals live in aquatic habitats, both in fresh and sea water. For example, an aquarium can be considered as a miniature aquatic habitat. The organisms living in such places are

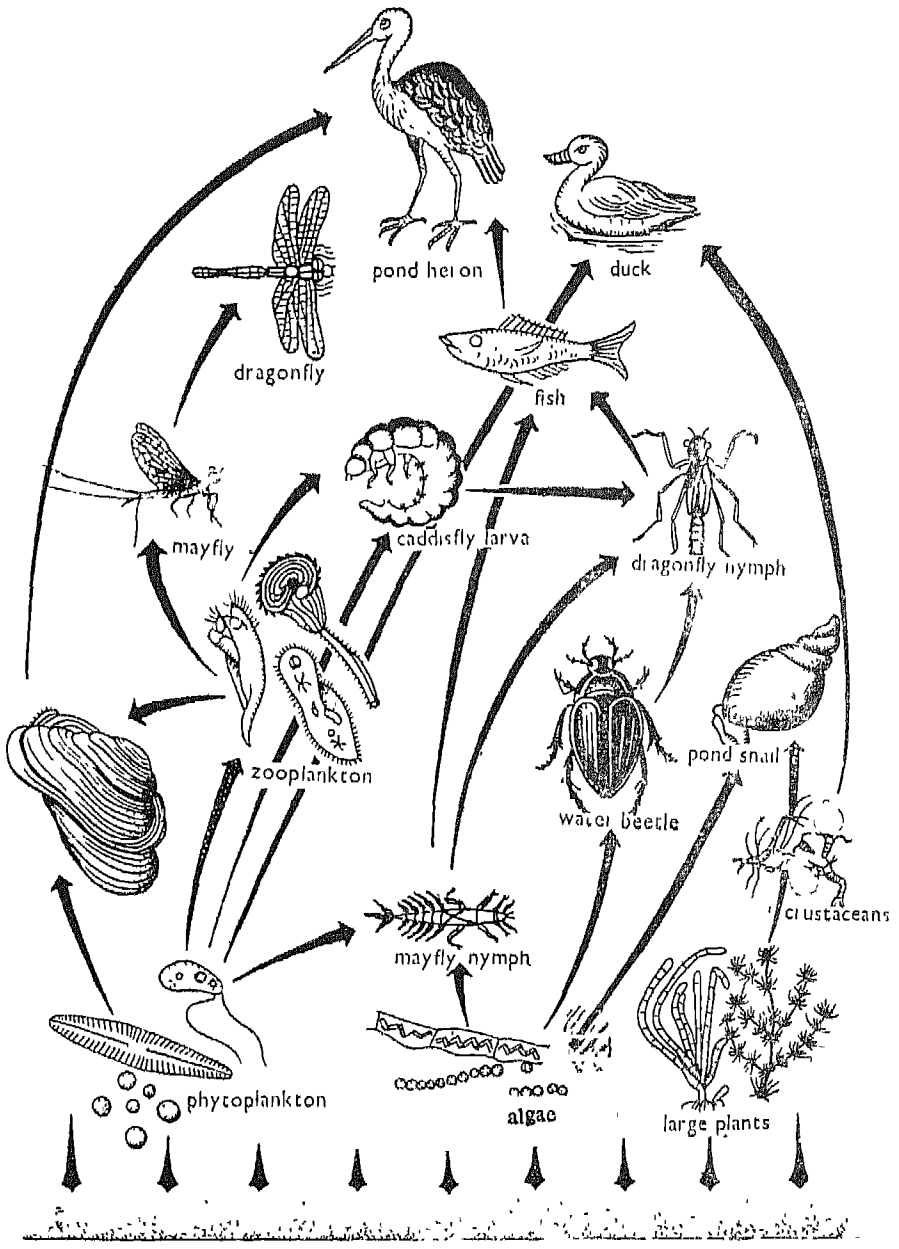

FIGURE 4.3 Food web in freshwater pond.

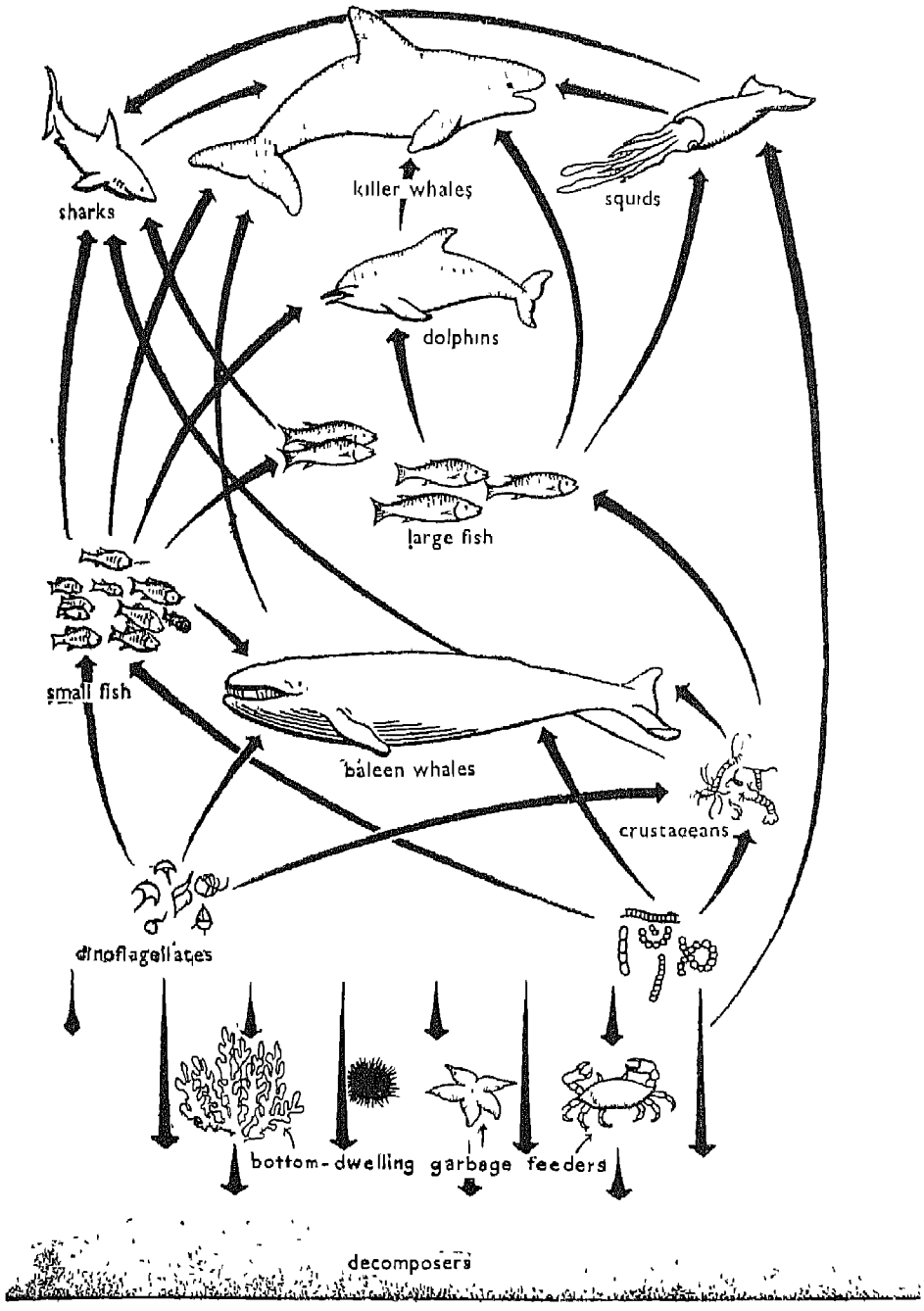

FIGURE 4.4 Food web in sea.

obviously interdependent for their food needs. Their food webs are equally as complex as those of the land communities. Some common relationships of organisms of freshwater and those of the sea are shown separately in figures 4.3 and 4.4.

From the information given in the above figures, complete the following assignment :

1. Classify the organisms shown in each of the food webs into their food level categories, viz., the primary, secondary and tertiary.

It is important to note that food relations of organisms need not be confined to the habitat. Often, a land animal may be dependent for its food on aquatic organisms. Man is a familiar example of this kind. Some of his food materials are obtained from organisms of aquatic habitats both fresh and sea water. This indicates that food webs are quite extensive and include organisms of diverse habitats.

(c) *What happens during the food transfers*

In our study of food chains we have seen that one organism forms the source of food for another, which eventually leads to the restoration of the raw materials to the earth. This, however, presents only a general picture of the food transfers but does not give out the main changes which food undergoes in the food web. Knowledge about such change is important because it enables us to know the relative quantities of food or the energy available for exchange from one organism to another.

Food in the main consists of carbohydrates, fats and proteins. When an organism consumes food, it breaks down the food into simpler substances like simple sugars, fatty acids and amino acids leaving the undigested remains to be thrown out. Generally, it is the sugars which are utilized in respiration and hence are oxidized. This results in the formation of carbon dioxide and water and the release of heat energy. As you have learnt earlier, respiration results in building up of the energy rich compound adenosine triphosphate (ATP), which provides the energy needed for all metabolic activities. It is estimated that only about half the total energy produced during the respiration is trapped into ATP. But again all of this energy is not utilized for the growth and development of the body. A large part of the energy in ATP is

used for transport of materials within the body and also in locomotion of the organisms. As a result, only 1-10% of the gross food taken in is incorporated into the body of an organism. The above changes are

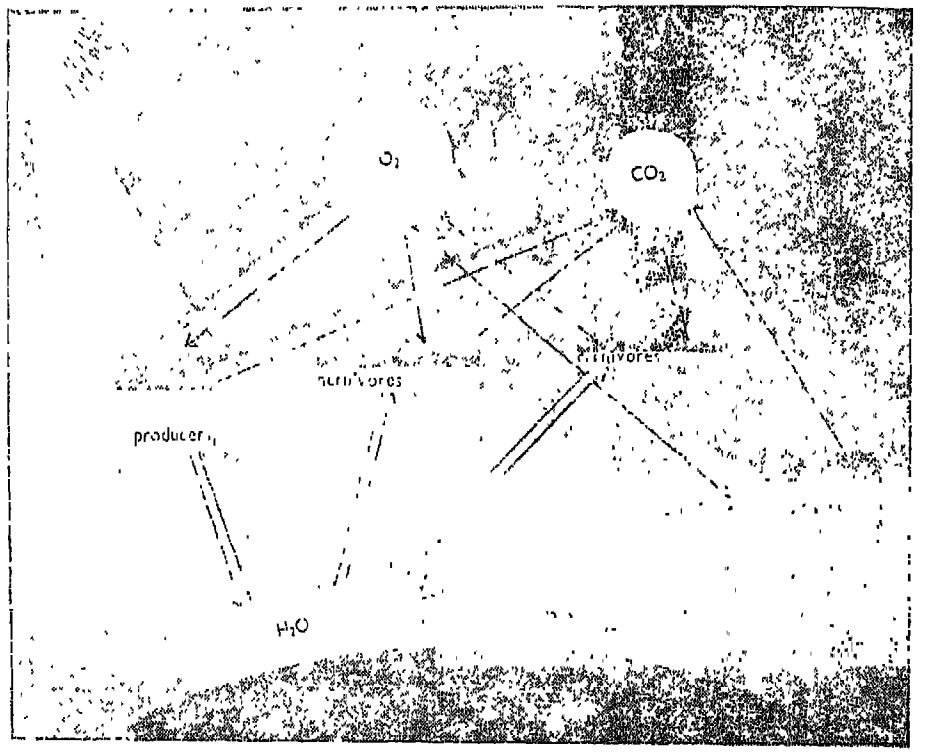

FIGURE 4.5 Circulation of matter in dissipation of energy.

diagrammatically shown in Figure 4.5. In green plants, food is utilized in the same manner as in the heterotrophs. But in their case, the food is synthesized in their own body.

Food utilization by the decomposers is different from other consumers. Although they break down most of the dead remains, only a part of it is consumed by them as food, while the remainder returns to the soil. Generally, at this stage, most of the elements such as nitrogen, sulphur, phosphorus, potassium, calcium, and magnesium, once absorbed by the green plants are returned to the earth. Thus saprobes are mainly responsible for replenishing the soil of its mineral components.

You can now understand how matter and energy transfers take place in a community. It may be noted that the carbon dioxide drawn from the atmosphere by the green plants for photosynthesis is restored at every link of the food web. On the other hand, the minerals absorbed from the soil by the green plants are released back mostly by the saprobes. From this it is clear that the materials drawn from the earth by the organisms for their use, do not undergo any loss ; they merely change from inorganic forms to organic and *vice versa* in a cycle.

The light energy derived from the sun is first converted into chemical energy by the green plants during photosynthesis. Later, as the heterotrophs obtain their food from the plant remains, a part of the energy is lost as heat to the environment during their respiration and other metabolic activities. The energy which is utilized in the synthesis of body materials by each organism is also finally lost to the environment in the same manner, when these organisms are consumed as food by others. Hence the light energy is partly lost to the atmosphere. Thus, for life to continue, oxygen, carbon dioxide, water and mineral salts are available on the globe, but light and heat energy are obtained from the sun. The sun is, therefore, a must for the sustenance of life on this planet (Fig. 4.5).

(d) *Biomass in relation to food levels*

It was mentioned earlier that the rate of utilization of food by organisms is not more than 10% of their intake. But to have an idea of the relative amount of biomass or the body matter built up in each species of a food chain, it is first necessary to know the rate of synthesis by the producers which provides the starting material. The inorganic matter synthesized by the green plants is called the primary product. It is usually estimated in terms of grams of dry weight of vegetative matter per day per square metre. This can be estimated as in the following :

Practical

1. Three pots, each containing 15 day old mustard seedlings (or of any other plant that can be easily grown) are suitable for the purpose of the experiment. See that same sized and equal numbers of the seedlings occupy

a 10 cm^2 area. Label the pots as A, B and C. The experiment can start early in the morning.

2. Remove the seedlings carefully from pot A wash their roots gently but thoroughly to separate the soil particles adhering to them. Dry them thoroughly in direct sun for 2 or 3 days (drying can be speeded up if an incubator is available).
3. Water the pots B and C sufficiently. Then transfer pot B to the open sun and pot C to an absolutely dark place for the whole day. (If experiment cannot be started right early in the morning hours, it can start around 10 or 11 a. m. and continue in the next 5 or 6 hours ; in this case, the duration of the experiment should be calculated as half of the day length of the place of the experiment).
4. At the end of the experiment, remove the seedlings from B and C and carefully free their roots of soil particles by washing thoroughly. Dry them separately.
5. Determine the dry weights of the plants from the three pots A, B and C. Find out the primary productivity from the dry weights obtained as in the following :

Primary productivity = 100 [(B — A) + (A — C)]

(If B and C were treated for only half the time as noted above, double the value derived above).

Compare your results with those obtained by the other groups of your class. Also note the values given in Table I, with which the primary productivity determined by you is comparable.

Answer the following:

1. Why should the value (A — C) be added to the value (B — A)? and also why should the sum total (B - A) + (A — C) be multiplied by hundred.
2. Do you consider that the primary productivity will be the same from one day to the other or will it vary?
3. In what way does the value determined by you differ from those given in Table I.

Food pyramid : In an earlier lesson you had learnt how organisms of a community are recognized into different food level categories depending on their food habit. Since the rate of assimilation of food at successive

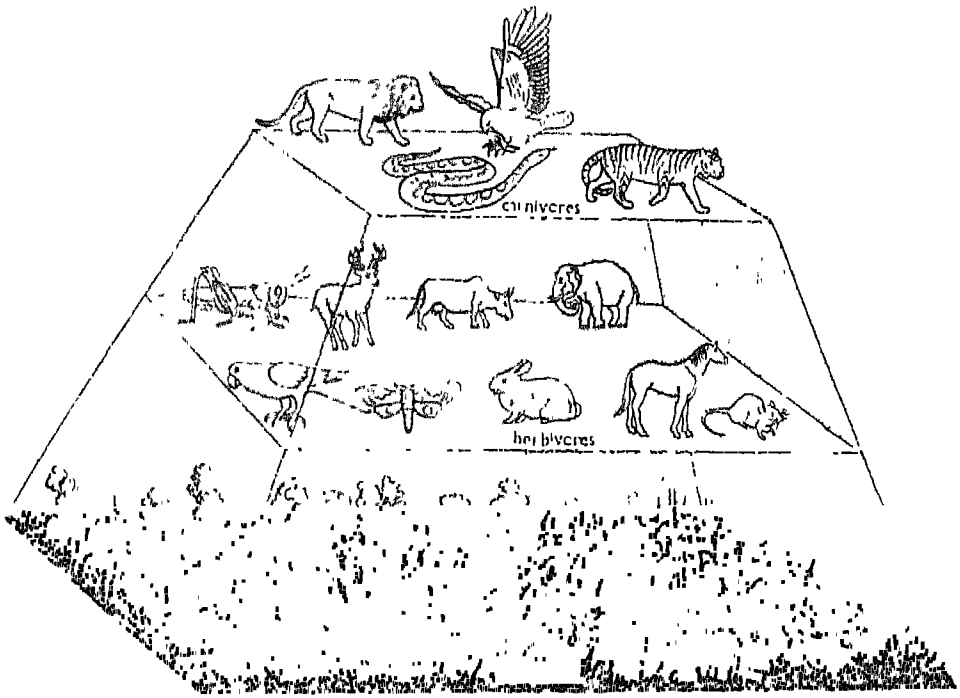

FIGURE 4.6 Food pyramid.

food levels is only up to 10% of the intake, the available food or biomass diminishes up to 90% from producers to herbivores and from herbivores to carnivores. Thus the quantity of biomass tapers off like a pyramid from the producers onwards. It is therefore referred to as food pyramid (Fig. 4.6).

Ocean as a food farm

With the rapid growth in human population, demand for food is increasing from year to year. Although this is a grave challenge which man faces today, it may be possible to meet this through scientific efforts. Primarily, it is necessary to keep the growth of population in check so that the demand for food is reduced. Secondly, it is important

to tap new sources of food. For this it is necessary to have a knowledge of the primary productivity of different natural habitats as this would give us an idea of the habitats which are suitable for exploitation. In the following table average primary productivity estimates for various habitats are given :

Table I : Primary productivity of some natural habitats

S No.	*Type of habitat (s)*	*Primary productivity*
1.	*Desert*	*Less than* 0.5 *g*
2.	(a) *Grass lands* (b) *Deep lakes*	0.5—3.2 *g*
3.	(a) *Moist forests* (b) *Shallow lakes* (c) *Moist grass lands and moist agricultural lands*	3—10 *g*
4.	(a) *Mouths of certain rivers* (b) *Coral reefs* (c) *Fertilized alluvial soils* (d) *Agricultural lands cultivated year round*	10—25 *g*
5.	*Continental shelf waters of the sea*	0.5—3.0 *g*
6.	*Deep sea waters*	*Less than* 0.5 *g*

From the table it is obvious that only few natural habitats are as productive as river mouths, coral reefs and agricultural lands cultivated all round the year. The productivity of the ocean is as low as 0.5 to 3.0 g. But unlike the terrestrial habitats the oceans occupy a large area of the earth. Further, environmental factors like O_2, CO_2 and nutrients remain relatively stable in the ocean. Therefore, the overall productivity of food in sea is enormous and it is a dependable source for regular supplies of food. Of the various animals thriving in the ocean, fish, crabs and lobsters form important food of man. It is relevant to mention that the current output of the world's marine fish is about 60 million

tonnes per year. This gives an idea of the enormous quantity of food man derives from the sea. But considering the vast area of the sea it is estimated that the annual catch of fish can be doubled. The ocean is likely to become a major source of food for man in the near future.

Reproductive Relations

You have learnt how the living organisms are interdependent for their food requirements. Let us now study the reproductive relations among the organisms.

I. Reproduction

Reproduction is one of the important characteristics of organisms. But for reproduction life would not have continued on this globe. You know how the modes of reproduction range from very simple processes to highly complex mechanisms. In single-celled organisms like amoeba, reproduction is very simple, i.e., a fully grown cell divides into two, by binary fission. This process is repeated again and again so that if conditions are favourable for life, the species continues to multiply generation after generation. In multicellular organisms cell division mainly adds to the cell numbers and causes growth.

(a) *Sexual reproduction*

Organisms resorting to sexual reproduction usually produce gametes. The gametes from the parents unite to form the zygote which later develops into an individual. This type of reproduction may be advantageous as the characters inherited from the two parents sometimes provide the offspring with greater survival value. Sexual reproduction in animals involves interdependence of individuals of opposite sexes. This is also true in the case of plants adapted to cross fertilization.

(b) *Animal courtship*

You already know that the male frogs during the mating season produce a croaking noise which is said to attract females. Some birds provide us with very interesting examples of courtship in the animal kingdom. They attract each other by song, colour and dance. The

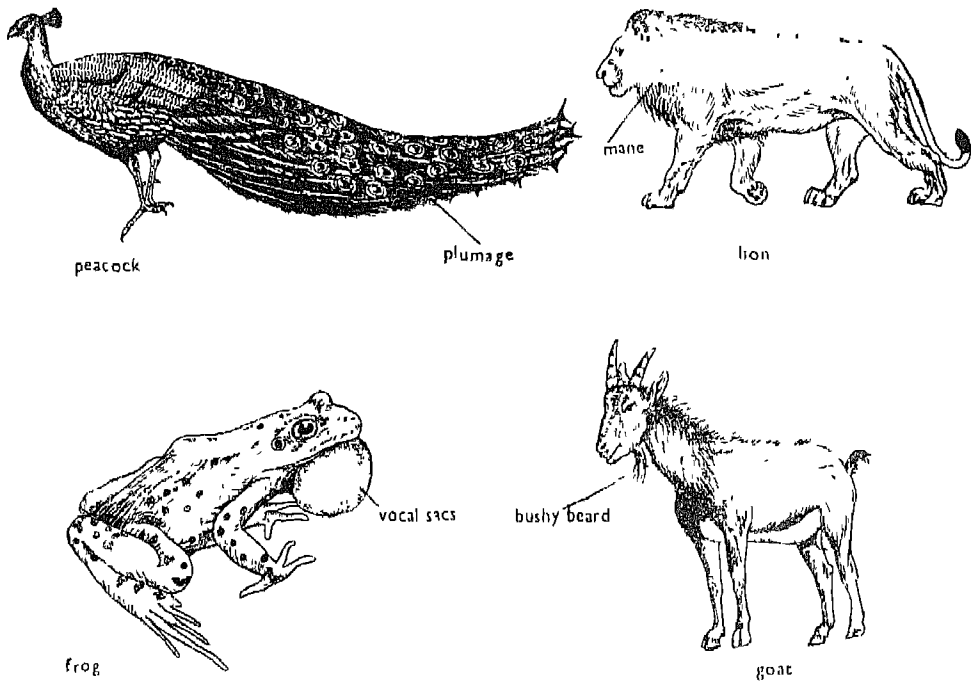

FIGURE 4.7 Examples of courtships among animals.

peacock has a beautiful plumage which when expanded is said to attract the peahen (Fig. 4.7).

The bushy beard in goats, the coloured patches on the underside of monkeys, the mane of lion are a few of the male characteristics that appear to attract the females of their species. Peculiar odours also play an important role in attracting the individuals of the opposite sex. In the elephant, the camel and the goat, there are special glands in the males which have a powerful odour. These are some of the common examples of courtship where the opposite sexes come together.

II. Insect pollination, a case of plant and animal interdependence.

In many plants, instead of natural agencies like water or air, animals bring about cross-pollination. This is made possible due to possession of special floral parts and strong odours to attract them. Let us now see why insects and other animals visit flowers and how they are attracted to them.

(a) *Flowers and animal food*

It is a common observation that butterflies, bees, etc., visit flowers for food. Many insects depend on pollen for their food. The nectar found in the flowers provides food not only to many insects but also to some birds. Often ants are seen visiting the nectaries in flowers long before they are open. Generally the nectar or sugary juice is collected at the base of the ovary. Insects and birds have to reach innermost parts of a flower to obtain it. While doing so they pollinate the female receptive organ of the flower, the stigma, with the pollen already collected from similar flowers they have visited before.

Practical

1. Try to observe which flowers butterflies and beetles visit frequently in the garden.
2. Collect these insects with the help of a net.
3. Collect flowers which have been visited by these insects.
4. Observe the pollen found sticking on the legs and the body (specially attached to the hair) of these insects, under microscope and make a sketch of the same.
5. Dissect the anthers of the flowers you have collected and observe the pollen under a microscope. Make a sketch.
6. Compare the two sketches.
   (i) Is the pollen from the flowers similar to those found on the body of the insect ?
   (ii) What is your inference ?

(b) *Insects as pollinators*

Most of the flowers are simple and can be pollinated by the insects that visit them. Of these, insects which have hairs on their body will facilitate pollination rather easily as there is a greater possibility of pollen getting attached to them. Some flowers are so constructed that they can be pollinated only by a particular type of insect.

Insects like the honey bees, bumble bees, butterflies and moths have a special adaptation for this purpose. The long proboscis of the bee is specially adapted to suck nectar from the base of flowers and while

doing so the pollen from flowers they visit sticks to the hairs on their body. The honey bees have flat areas with long hair called ' pollen

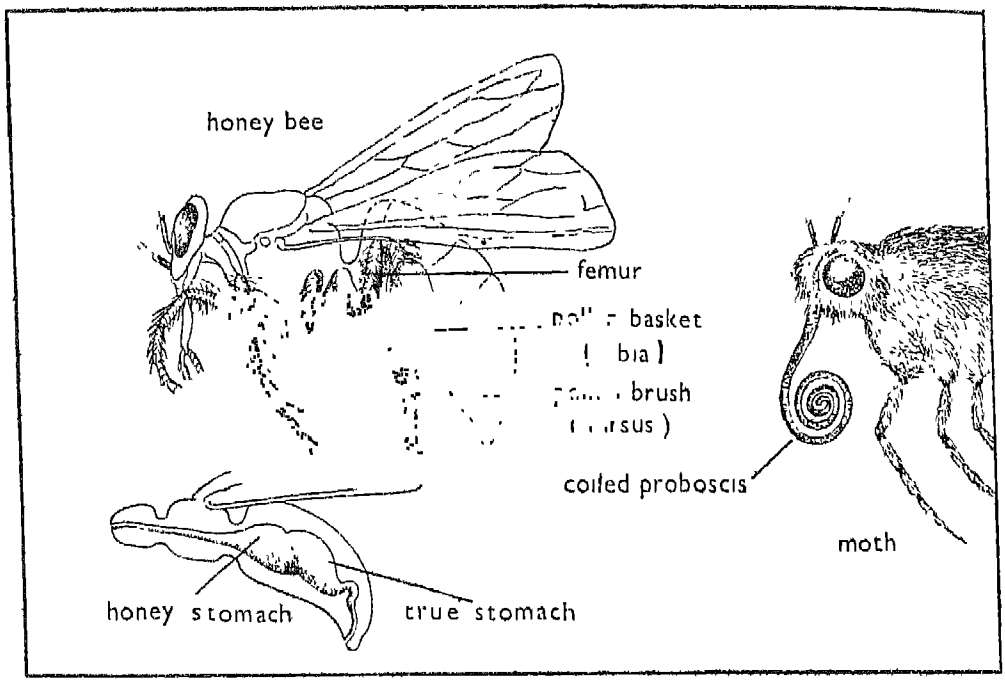

FIGURE 4.8 Pollinating insects.

baskets ' on their hind legs which help in collecting pollen (Fig. 4.8). They also have special sacs in their stomach to collect the honey which is regurgitated later when they return to the hive. The watchspring-like proboscis of a butterfly or a moth (Fig. 4.8), when uncoiled, is long enough to reach the base of long tubular flowers for the nectar.

The flowers which are pollinated by insects usually have bright colours (Fig. 4.9). Experimentally it has been shown that certain insects have a preference for particular types of flowers. Bright coloured flowers like the orchids and sweet peas are usually visited by the bees. In the flowers of cotton there are dark coloured patches which attract insects to the interior where nectar is available. The dark conspicuous lines on the petal known as 'guide lines' (Fig. 4.9), as found in bean, morning glory, and passion flower and the dark coloured patches at the base of the flowers in bhendi (Fig. 4.9) also attract the insects to the flower.

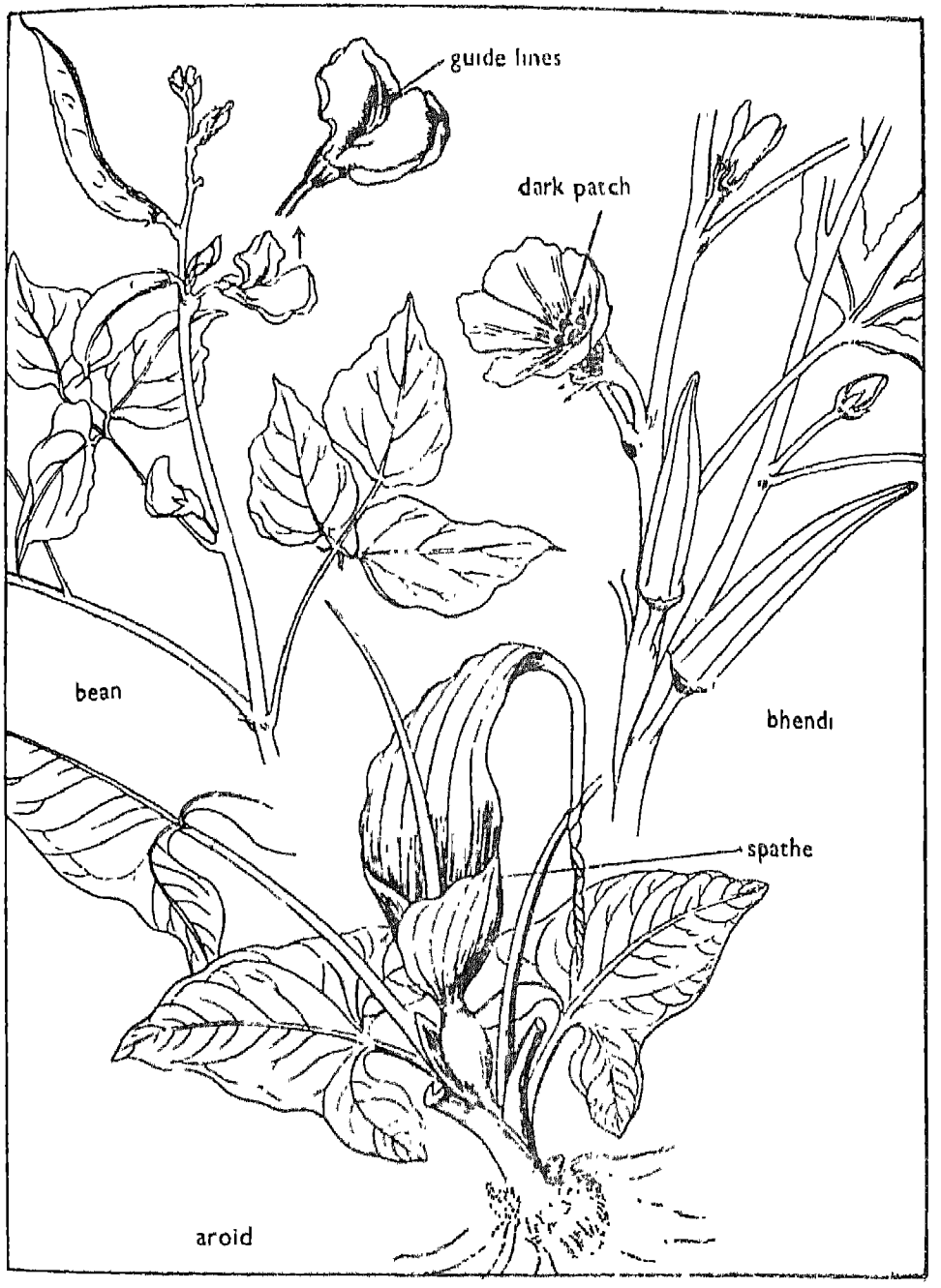

FIGURE 4.9 Some flowers adapted for pollination by insects.

Scents and strong odours of some flowers help in attracting insects. The duck flower and aroids (Fig. 4.9) emit a very pungent smell which attracts flies. Sometimes we can even see the flies under the covered spathe. There are, however, some sweet smelling flowers as madhumalati, jasmine or the night queen which attract insects by their fragrance.

We see that both insects and flowers are interdependent. The insects obtain their food from the flowers, while the flowers get pollinated by the insects. This interdependence seems to have evolved together during the long period of evolution and today one may not survive in the absence of the other.

Practical A

Collect some flowers from your school garden with the permission of your teachers and tabulate their characteristics according to the criteria given below :

Name	*Colour*	*Presence or absence of nectar*

With the help of data you have tabulated, try to answer the following questions :

1. What are the parts of the flowers which are most coloured and where are the guide lines located ?
2. Do you find any difference between the flowers which have scent and nectar and those that do not possess any ?

Practical B

1. Select a twig of Okra (*Abelmoschus esculentus*) bearing unopened flowers. Tie a polythene bag about 3 cm long enclosing one or two flower buds and fasten it carefully to the twig in order to prevent cross pollination.
2. Select a branch of Indian periwinkle (*Catharanthus roseus*) with unopened flowers and tie a polythene bag as above, covering them securely.
3. Three or four days after the flowers have opened in both the plants, examine the ovaries.
4. Compare the ovaries of the bagged flowers with those of the unbagged flowers.
5. Make a note of the insects that visit both the plants.
6. Tabulate your results as follows :

Flower	*Whether bagged or not*	*Seeds developing or not*
Indian Periwinkle	*Bagged*	
	Unbagged	
Okra	*Bagged*	
	Unbagged	

Answer the following questions :

1. What differences do you find between the ovaries of the bagged and unbagged flowers ?
2. In which are the seeds developing ?

(c) *The story of fig pollination*

Various species of figs and wasps of the genus ***Blastophaga*** provide very interesting examples of adaptations which explain their interdepen-

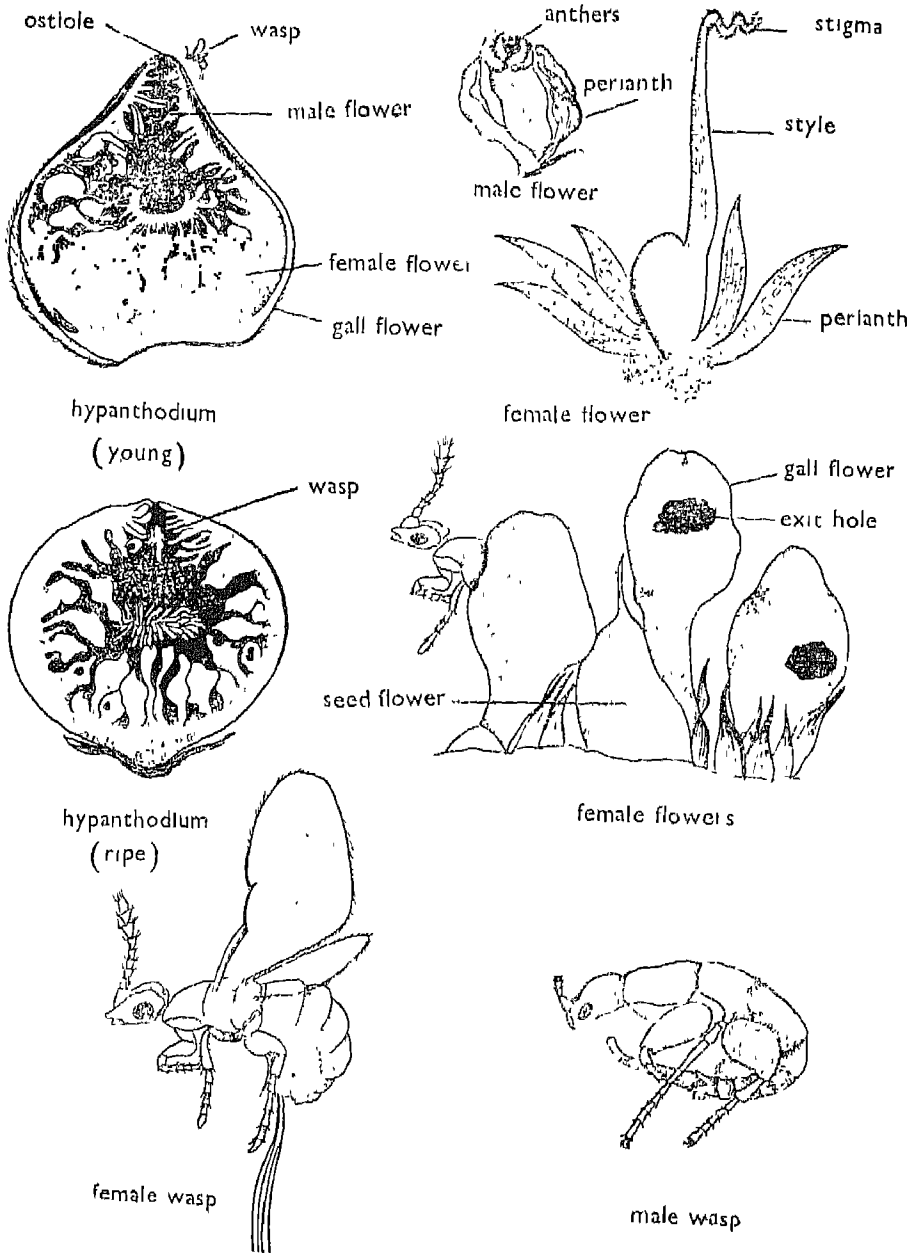

FIGURE 4.10 Pollination in fig by wasp.

dence. Here we shall discuss some details of pollination with respect to the peepal tree. The special inflorescence of this tree, called the hypanthodium (synconium), has the flowers hidden inside a chamber (Fig. 4.10). The entry to this chamber is through a small opening at the top. The male flowers are borne at the top near the opening whereas the female flowers are at the base (Fig. 4.10). A gravid female wasp enters the inflorescence through the opening and in doing so may even lose its wings. Once it reaches the chamber it starts to lay eggs in the ovaries of the flowers and dies. These eggs hatch later into males and females. The males come out through a hole from the ovary, while the females remain inside them. Later on the male wasps copulate with the female still remaining within. After mating, the females come out from the ovaries of the gall flowers. The developing young ones utilize the tissue of the ovules as food. They try to come out of the fig through the opening and while doing so get laden with pollen of the male flowers (Fig. 4.10). These females may visit other figs and bring about cross pollination. The fig has benefited by the wasp in securing pollination while the wasp has obtained food and shelter, to complete its life cycle. The close association of the fig and wasp provides a clear example of mutual interdependence to such a degree that one cannot obviously complete its life cycle without the other.

(d) *Birds and bats as pollinators*

Like the insects, some birds depend on nectar in flowers for food. Humming birds (Fig. 4.11) in a day are known to gather nectar amounting to as much as one half of their own body weight. The birds also look for insects in the flowers. Apart from humming birds, sunbirds, lorys and lorikeets (Fig. 4.11) are some of the important pollinators. Some of these birds have long bills and tongues which can be thrust deep in the flower to get honey. By doing so they pollinate the flowers with the pollen they have collected from the flowers they have visited earlier. The flowers visited by birds are mostly tubular or funnel-shaped, e.g., the morning glory.

The bats are nocturnal animals, and feed on the petals, pollen and fruits. The flowers, which bats visit, are usually found in bunches on high trees easily visible at night, e.g., silver oak.

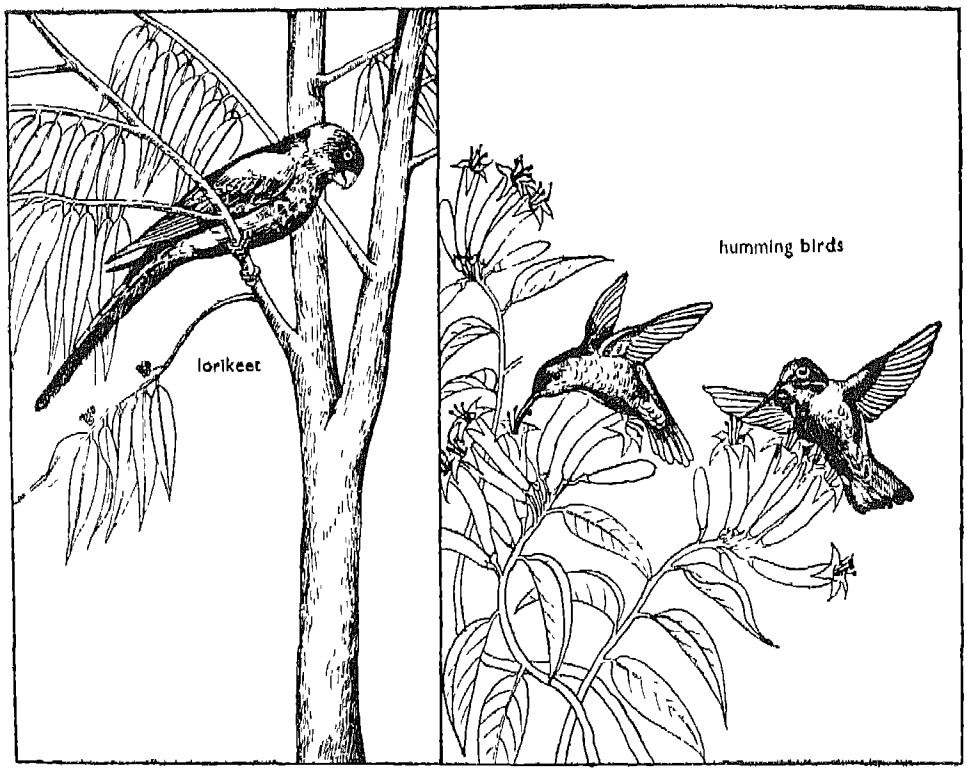

FIGURE 4.11 Examples of pollinating birds.

Web of Life

So far you have studied some of the aspects of food and reproductive relationships of organisms. But it should be clear that organisms are related to one another in several other ways. This can be illustrated by considering the relations of organisms harboured by trees, say, the banian, peepal or neem. In the litter and debris accumulating below the trees a number of insects, worms and various micro-organisms lead their lives, where they obtain shelter, protection and food. Similarly, a number of organisms thrive in the crevices of the tree trunks and branches. The birds build their nests on tall branches and are able to protect their young from predators. Similar relationship can also be noted amongst organisms found in a small pond or tank.

There is yet another aspect of association. Organisms may remain in contact with each other only for a short period or for a longer

duration. We find that the period of contact depends on the habit of the species concerned. For example, the female mosquitoes come into contact with their hosts like the human being for short periods. But if you recall some of the food habits you have studied, you will see that organisms are associated with others intimately and for a greater part

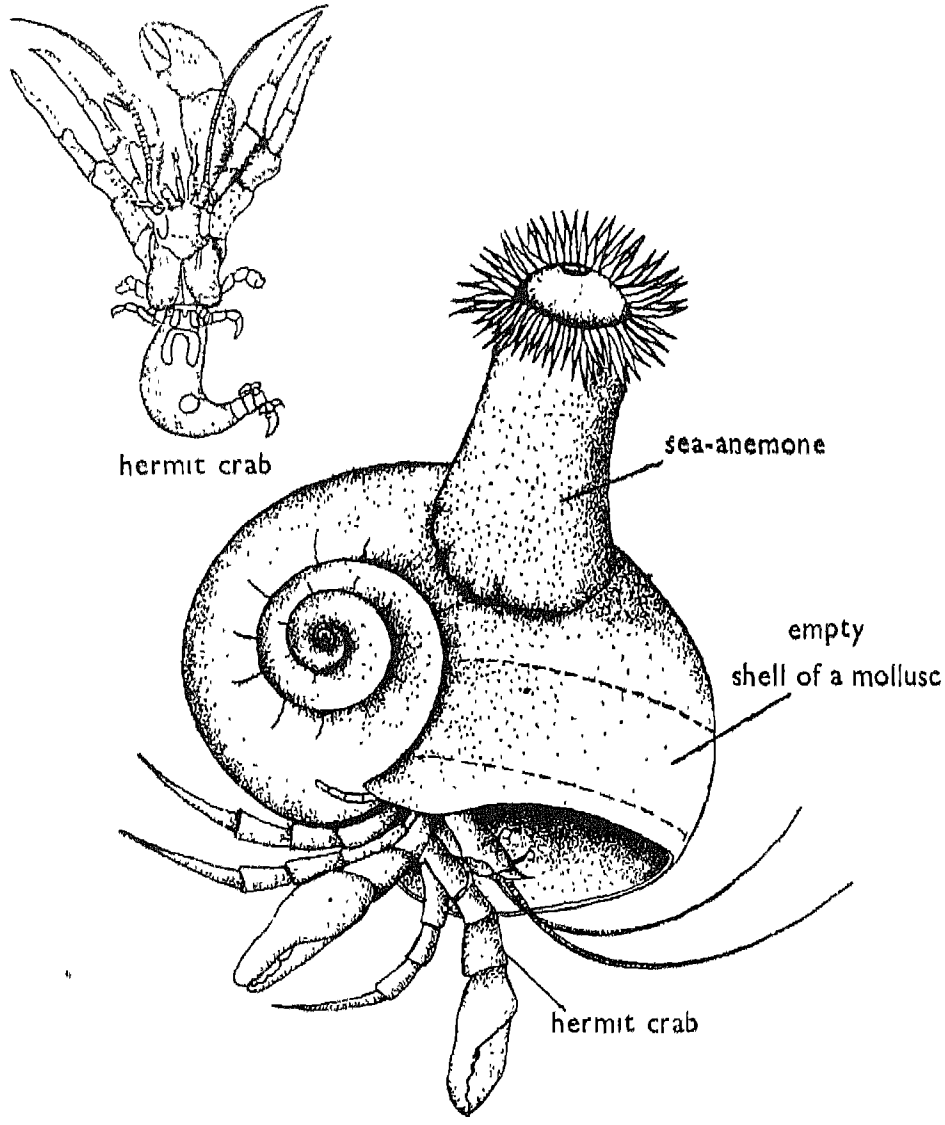

FIGURE 4.12 Association of hermit crab and sea anemone.

of their life. For example, ticks, mites, aphids, and lice all live for most of their life on the body of the host itself. Similarly, organisms living as mutualists also associate with each other for most of their life. For example, the root-nodule bacteria live in the root of leguminous plants; certain algae and fungi live in close association as in lichens. The hermit-crab takes shelter in an empty shell of the mollusc, a sea-anemone may fix itself on the surface of this shell Fig. 4.12. Since sea-anemones have stinging cells, other sea animals do not venture to approach them. Thus sea-anemone provides the hermit crab with protection. At the same time the sea-anemone is transported from place to place, as the hermit crab goes about in search of food. A number of such examples can be found which indicate that different organisms are associated with each other for different periods of their life.

It is clear that relationships of organisms are quite intricate and that they are governed by their needs—food, reproduction, shelter and protection. Hence, if a community of organisms thrives for a prolonged period in a given habitat, it indicates that there is a balance between the needs of its members and the resources available in the habitat. Forests, deserts, large lakes and oceans represent self-sufficient communities of this kind.

CHAPTER V

CYCLES OF MATTER

Introduction

All things in the Universe, such as rocks, soil, water and air are made up of matter. Living beings are no exception to this rule. They are built of the same materials that make up the non-living. In what form do the non-living materials exist in nature? You have learnt in your study of chemistry that they occur as elements and compounds. The elements are the basic units of which both the living and non-living things are composed. In all 103 chemical elements are known to-day.

Chemical composition of living matter

A. Water as the major constituent of living matter

1. Take a piece of meat or the white of an egg or any plant material such as the fresh, green leaves (weighing about 100 g.) of any herb.
2. Weigh the above material.
3. Transfer the material to an evaporating dish.
4. Place the dish with its contents on a tripod stand and heat it gently.
5. As the heating continues, place a dry clean cold plate over the evaporating dish.
6. Lift the plate after a while. Examine its under-surface and observe drops of water due to condensation of water vapour.
7. Heat the material till all the water has evaporated and its weight becomes constant.

8. Remove the dish from the tripod stand and cool it in a desiccator.
9. Weigh the contents of the dish again.

Answer the following questions :

1. Is there any difference between the first and final weights of the sample used ?
2. What is the loss in weight of the material due to ?
3. What do you infer from the experiment ?

The experiment conducted above reveals that water is the major constituent of all living matter. Oxygen and hydrogen are two constituent elements of water. Obviously these two elements make up a large part of the weight of a living organism.

B. Other components of living matter

In the above experiment the dried matter left behind is mostly organic in nature. On further heating in a crucible to a high temperature it gets charred and finally may get ignited showing that the dried matter contains carbon. The other principal constituent of living matter is *nitrogen*. All these four constituent elements (C, N, O_2 and H_2) are needed in sizable amounts for an organism.

The residue left behind, after completely burning the organic matter, is *ash*. Usually it is either white or light grey in colour. Chemical analysis of ash shows the presence of potassium, calcium, phosphorus, magnesium, sulphur and iron. These occur in small quantities. These ten elements, as shown in Table I below, account for about 97.48% by weight of a maize plant. These are considered essential for healthy growth of a plant. The remaining 2.52% is constituted of elements which are present in very minute quantities. These are called the *trace elements*. In all 30 to 40 elements may be present in the living organisms.

Source of the constituents of living matter

Where from do living organisms get their supply of the component elements ? To determine this the following experiment may be performed :

1. Take a wide-mouthed glass bottle of 25 ml capacity.

TABLE I

Weights of the elements present in a mature maize plant. Average dry weight of the plant was 835.9 grams.

Name of the elements	*eight in grams.*	*Percentage of total dry weight.*
Oxygen	371.4	44.43
Carbon	364.2	43 57
Hydrogen	52.2	6.24
Nitrogen . .	12 2	1.46
Potassium	7.7	0.92
Calcium	1.9	0.23
Phosphorus .. .	1.7	0.20
Magnesium	1.5	0.18
Sulphur	1.4	0.17
Iron	0.7	0.08
Others (silicon, aluminium, chlorine, manganese.. and undetermined)	21.0	2.52

2. Clean it thoroughly and then rinse with small amounts of distilled water several times.
3. Wrap the sides and bottom with aluminium foil so that light is cut off.
4. Obtain a cork with a hole (about 13 mm in diameter) in the centre which fits into the mouth of the bottle.

5. Split the cork vertically into two.
6. Weigh 0.3 g of potassium nitrate and 0.1 g of calcium chloride.
7. Dissolve both the salts in 200 ml of distilled water.
8. Transfer the salt solution to the wide-mouthed bottle.
9. Obtain a healthy, vigorously growing (8-10 cm high) tomato or any other seedling with its root system intact.
10. Immerse the roots of the seedling in water in a small dish and carefully wrap a strip of cotton around its stem just below the leaves until the cotton roll is of the size of the hole in the cork.
11. Insert the seedling carefully through the hole in the cork so that its roots extend into the salt solution in the bottle. See that the cotton roll fits into the hole in the cork and holds the plant in position.
12. Place the apparatus in diffused light.
13. After a week remove the plant carefully from the bottle.
14. Measure and record the volume of the remaining salt solution.
15. Pour the solution in an evaporating dish that has been weighed previously and heat it on a tripod stand.
16. Remove the dish when the water has evaporated.
17. Cool the dish in a desiccator.
18. Weigh the dish again with its contents and calculate the weight of the salts left behind.

Answer the following questions :

1. How much water has been absorbed by the roots ?
2. Is there any difference between the weight of the salts in the beginning and at the end of the experiment ?
3. If so, what does the difference in the two weights of the salts represent ?

It is evident from this experiment that land plants absorb water and minerals in solution through their roots. The roots are normally embedded in the soil. The plants in general, therefore, obtain water and minerals from the soil. The gaseous requirements (carbon dioxide and oxygen) are obtained from the atmosphere. Thus the *atmosphere*

and the *soil* are the only two sources which supply nutrients to plants. Animals mostly depend upon plants directly or indirectly for nutrients.

A. *Atmosphere*

Recall the composition of atmospheric air which you have already studied in chemistry. What are its major constituents and in the what percentage do they occur ? All components of air, except the inert gases, serve as plant nutrients. Carbon dioxide is needed for photo-synthesis and oxygen for respirartion of both plants and animals.

B. *Soil*

The soil contains water, usable nitrogen and other inorganic nutrients. Plants obtain nitrogen chiefly from nitrates and ammonium salts present in the soil. The phosphates and sulphates in soil are the sources of phosphorous and sulphur, respectively. In short, plants obtain all the component elements from the soil except carbon and oxygen. Within their bodies these elements are locked up in organic combination in the protoplasm. It is, therefore, evident that the two worlds, the living (organic) and the non-living (inorganic) are closely bound together.

Most of the elements found in plants are absorbed from the soil and returned to the same source sooner or later. The series of events takes place continually in a characteristic way, time and again, in regular order. The flow of body constituents of an organism to and from the source constitutes a *natural* cycle. Of several natural cycles known, you will study some of the important ones, namely of carbon, oxygen, nitrogen and phosphorus.

Carbon Cycle

A. *Importance of carbon*

Life on earth is carbon-based. Carbohydrates, fats, proteins, amino acids and nucleic acids found in the living matter contain carbon.

B. *Source of carbon*

Wherefrom do the living organisms obtain their carbon ?

It is obtained from the environment where it exists in the following two forms :

(i) *Non-available form of carbon :* You have seen coal, petroleum and limestone rocks. These contain carbon. But this carbon as such cannot be used by plants. It is useful to them only when changed chemically into carbon-dioxide.

(ii) *Available forms of carbon:* Among the living forms, green plants alone can make use of carbon as carbon dioxide. Carbon dioxide is produced during respiration, in combustion and in the slow oxidation of organic matter and is restored to the atmosphere where it constitutes 0.03% to 0.04% of the air. Carbon dioxide also occurs dissolved in water.

C. *Carbon cycle* (Fig. 5.1)

For an easy understanding of the carbon cycle, we start with the green plants which are autotrophic. As established in the experiments on photosynthesis given in Book II, carbon dioxide is utilized by plants

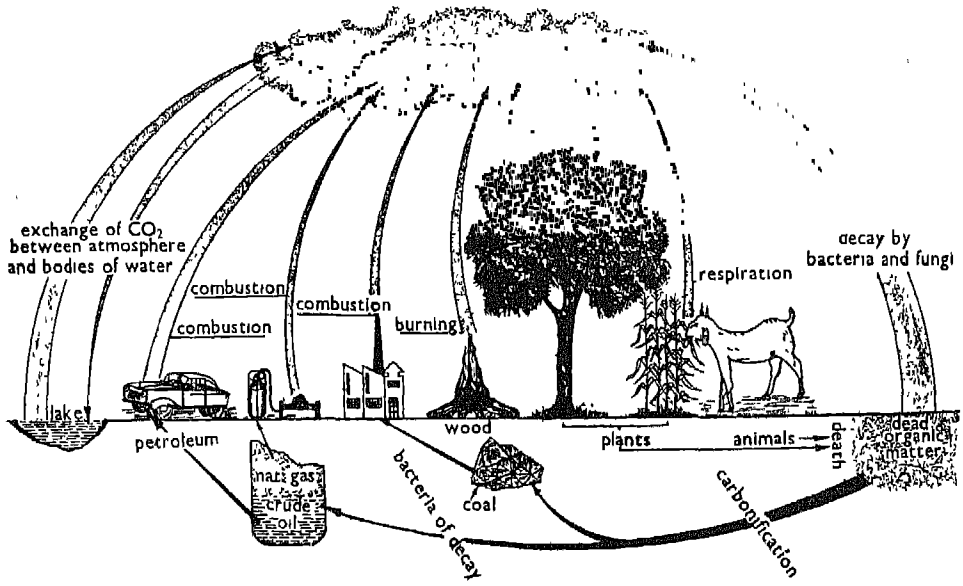

FIGURE 5.1 Carbon cycle.

during this process. It is incorporated into the organic food compounds within the cells. The green plants, in fact, are virtually the only food-makers on the earth and are, therefore, called the *primary producers.* Animals directly or indirectly depend on plants as a source of food. So they are called the *food-consumers.* A good amount of carbon remains locked in the bodies of primary producers and food consumers. A part of it is not returned to the atmosphere even after death of organisms and is lost to the cycle for long periods of time. The bodies of numerous plants and animals which died several million years ago, were converted into " fossil fuels ", such as coal, oil deposits, natural gas and related substances by the action of heat, pressure and other factors. This process of conversion is called *carbonification.* These products serve as natural deposits of carbon.

In spite of its consumption and subsequent storage in the bodies of organisms the amount of carbon dioxide in the air remains practically unaltered. You have performed an experiment with a potted balsam plant covered with a belljar (Book II p. 56) showing that some carbon dioxide is released as a by-product in plant respiration. It may be used in photosynthesis again or added to the air.

Experiment

1. Take a clean test tube.
2. Pour 10 ml clear, freshly prepared lime water into it.
3. Blow gently through a soda straw into the lime water for about 3 minutes.
4. Note what happens and record the results.

This experiment shows that carbon dioxide is produced in animal respiration as well. The gas released into the air in plant and animal respiration completes one possible carbon cycle. It is the shortest possible carbon cycle, which makes carbon again available to the living world.

Combustion or burning is another process which returns carbon dioxide into the air.

Experiment

1. Weigh 1 g of charcoal and grind it into fine powder,

2. Mix this powder with an equal amount of cupric oxide.
3. Transfer the mixture to a dry, clean, hard glass test tube.
4. Holding the tube in a test tube holder, heat it strongly over the flame of a spirit lamp for about 3 minutes.
5. During the operation keep the test tube in a slanting position with the mouth away from you.
6. Introduce a burning splinter in the mouth of the test tube.
7. Note what happens and record the result.
8. Now plug the mouth of the test tube with a one-holed rubber stopper carrying a delivery tube, the open end of which dips in clear freshly prepared lime water in a test tube.
9. Pass the gas evolved in the process for sometime into the lime water.
10. Note the change in colour of the lime water.

Answer the following questions :

1. What gas is produced by heating a mixture of charcoal and cupric oxide ?
2. Name some other substances of the same chemical nature as charcoal which give off carbon dioxide on burning.

Occasional forest fires and combustion of industrial fuels such as coal, oil, wood charcoal and natural gas return considerable amount of carbon dioxide into the air completing another possible carbon cycle. Occasional volcanic activity also supplies small amounts of carbon dioxide to the atmosphere.

Certain saprophytic micro-organisms (molds, yeasts and bacteria) also play a significant role in the carbon cycle.

1. Take 25 ml of freshly extracted grape juice or prepare 25 ml of 2% glucose solution in a test tube.
2. Add a little yeast cake to 5 ml of water and stir to form a creamy mixture.
3. Add the yeast mixture to the grape juice or glucose solution and stir again.
4. Plug the mouth of the test tube with an air-tight rubber stopper carrying a delivery tube.
5. Dip the open end of the long arm of the delivery tube into freshly prepared clear lime water.

6. Keep the apparatus at a temperature of about 30°C.
7. Note that bubbles of gas begin to pass into the lime water after some time.
8. Observe the change in colour of the lime water from time to time.

Answer the following questions :

1. What gas is responsible for the change in colour of lime water ?
2. What causes the production of this gas from grape juice or sugar solution ?
3. What do you call this process ?
4. To what main category of foods do the grape juice and glucose belong ?

Can you tell what becomes of the plant and animal debris when it is heaped into a pit and covered with earth ? The saprophytic micro-organisms present in the soil feed on the dead organic matter in nature. During this process the organic substances such as carbohydrates, fats and proteins are broken down into simpler compounds which also include carbon dioxide. The latter, among others, is put back into circulation in the air, soil or water, completing yet another carbon cycle. The bacteria and fungi which bring about this alteration are called *decomposers* and the process of decomposition is called *decay*. The breakdown of carbohydrates such as sugar and starch by the yeasts results in the production of carbon dioxide. Technically this process is known as *fermentation*. In fact all organic composition depends on microbial activity. But for it our planet would have been a refuse pile.

Similar to the carbon cycle in land plants and animals, the carbon dioxide taken up by aquatic plants during photosynthesis passes through a cycle of utilization. It is released as carbon dioxide during respiration and diffuses into the surrounding water.

It is evident from the account given above that carbon passes through a cycle of changes in nature. This circulation of carbon between the carbon dioxide of the atmosphere (or water) and the living world is termed the *carbon cycle*. Perhaps it started with the origin of green organisms on the earth and will continue as long as green plants can carry on photosynthesis.

Oxygen cycle

A. Importance of oxygen

Like carbon, oxygen is another major element found in living organisms. The carbohydrates, fats, proteins and nucleic acids all contain oxygen. In fact, oxygen is the main-stay of life on earth.

1. Take two stoppered belljars and two glass plates 25 cm square.
2. Place each belljar on a glass plate.
3. Under one of the belljars, say 'B' place a pot of vigorously growing mint.
4. Allow both the belljars to remain in the sunlight for several hours.
5. Now place a living young mouse with some food for it under each container.
6. Seal the containers to the glass plates to make them air tight.
7. Place both the containers in moderately bright light.
8. Observe for a couple of days what happens to the mouse kept under belljars 'A' and 'B'.
9. Lower a burning candle with the help of a deflagrating spoon in belljar 'A', immediately after the mouse dies in it.
10. Similarly introduce another burning candle in belljar 'B'. What happens to the burning candle and what happens to the mouse ?

Answer the following questions :

1. Why does the mouse under belljar 'A' die ?
2. Can you explain why it continues to live under belljar 'B' ?
3. What do you infer from this ?

The presence of oxygen in the belljar 'B' produced in photosynthesis keeps the mouse alive. How ? The energy locked up in the food molecules is released by oxidation in respiration. The released energy enables the organism to carry on all the activities of life such as digestion, assimilation, growth, movement, irritability and reproduction. In the absence of oxygen the mouse is unable to respire, all metabolic activities come to a stop and the organism dies.

B. Source of oxygen

Air is the source of oxygen and contains about 21 % of it. Oxygen is also available in water and certain food compounds in the combined form.

C. Oxygen cycle (Fig. 5.2)

Both land plants and animals acquire oxygen directly from the surrounding air. Aquatic organisms except those that breathe through lungs secure it from that dissolved in water. Oxygen is taken in by the

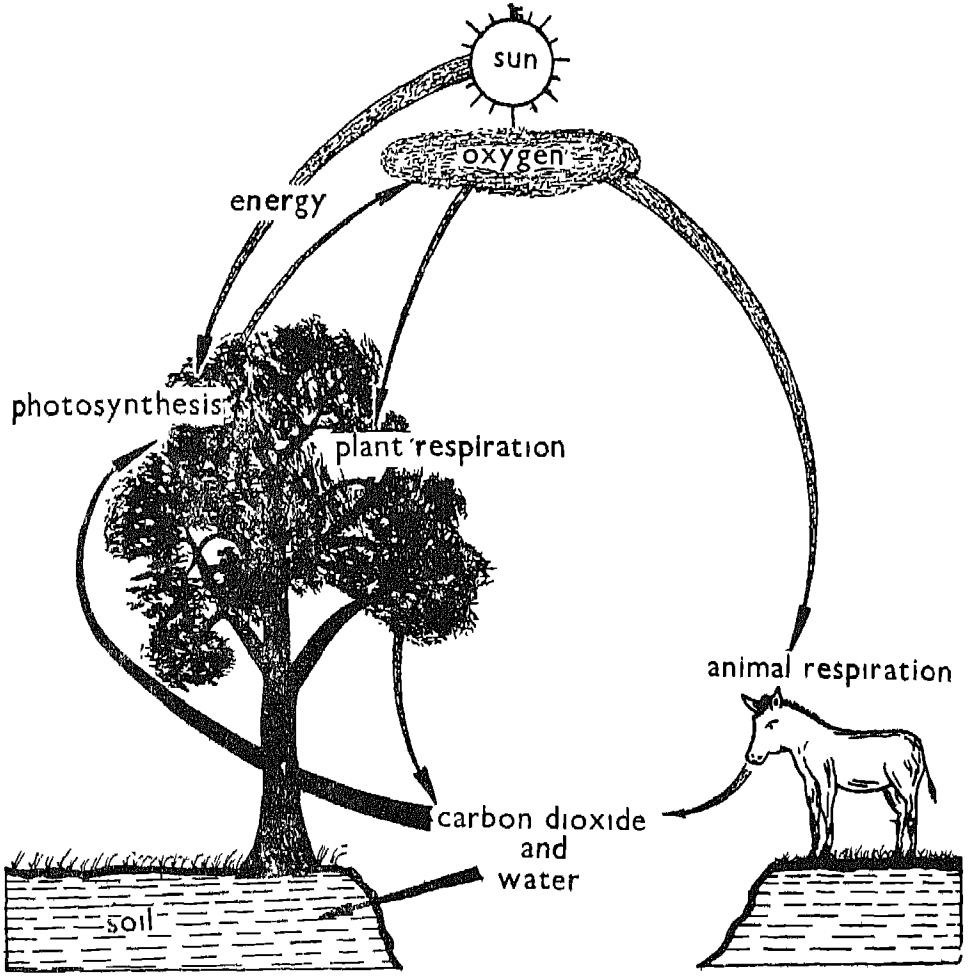

FIGURE 5.2 Oxygen cycle.

living organisms in the process of breathing and is utilized in cellular respiration. During respiration it combines with hydrogen and carbon forming water and carbon dioxide respectively. The carbon dioxide is given off into the atmosphere. The water is utilized by the organisms in various ways.

We shall now follow the chemical transformation which the water undergoes in the organism. A portion of it is given off. Some of it is used as a raw material in photosynthesis and oxygen is released as a by product. The released oxygen may be used again in respiration or added to the air to complete the oxygen cycle. The rest of the water is utilized as a source of the basic chemical elements (oxygen and hydrogen) in the construction of new protoplasm. The decay of dead organisms returns structural oxygen to the environment in the form of carbon dioxide or water and not in the form of oxygen.

The intake of oxygen into the organism and its ultimate release into the environment including the chemical changes that it undergoes within the body constitute the *oxygen cycle*.

Nitrogen Cycle (Fig. 5.3).

A. Importance of nitrogen

Nitrogen is an important constituent of proteins, vitamins, nucleic acids, many alkaloids and numerous other compounds, that are essential for the healthy growth of organisms. The effect of nitrogen on plant growth can be readily observed as follows :

1. Raise balsam or any other plant seedlings on sterilized sand in two earthern pots.
2. Water one pot with Knop's nutrient solution and the other pot with Knop's solution without nitrates and ammonium salts.
3. Compare the growth of the seedlings in the two pots and record your results.
4. What do you conclude ?

B. Expenditure and source of nitrogen

You may ask wherefrom the animals get their nitrogen require-

ments. Obviously it is from the plants. The plants in turn, obtain nitrogen mainly from the nitrates in the soil through the roots. When the crops are harvested, the soil becomes deficient in nitrogen because it has passed into the produce. A fraction of these salts may be lost from the soil through the activity of certain micro-organisms. Erosion, excessive rains and irrigation also cause the depletion of nitrates and ammonium salts from the soil. Do you know what would happen if this loss is not made good? To know this, you have to study the sources of nitrogen.

With the exception of certain micro-organisms, plants are unable to utilize atmospheric nitrogen in the molecular state. They use it most frequently as nitrate ion, NO_3. These ions accumulate into the soil through weathering of rocks. Nitrate ions are also added to the soil by other natural forces. During lightning and rain, atmospheric nitrogen may be oxidized to nitrous oxide which later combines with water vapour to form nitrous or nitric acid. During rain it reaches the soil where it combines with bases to form nitrites and nitrates which in turn become the available source of nitrogen for plants to absorb.

Organisms retain nitrogen till death. A countless number of organisms consume the dead bodies and remove them from the scene. If these dead plants and animals were not to decay, there should be unlimited heaps of dead matter. But do we find it to be so ? No. What happens to the dead organisms then ? Among these scavengers are certain micro-organisms called *saprophytic bacteria*, which can be observed in a decaying piece of meat.

1. Put a decaying piece of meat in a sterilized test tube.
2. Add a little sterilized distilled water and shake vigorously.
3. Take a drop of this liquid on a clean slide and stain in methylene blue or crystal violet with eosin or safranine combination.
4. Place a cover slip and examine the slide under high power of the microscope.
5. What do you observe.

Of these saprophytic bacteria, the *bacilli* use the dead organic remains as food and liberate ammonia as a by-product which in turn is utilized by other bacteria like *Nitrosomonas* and *Nitrosococcus*. The

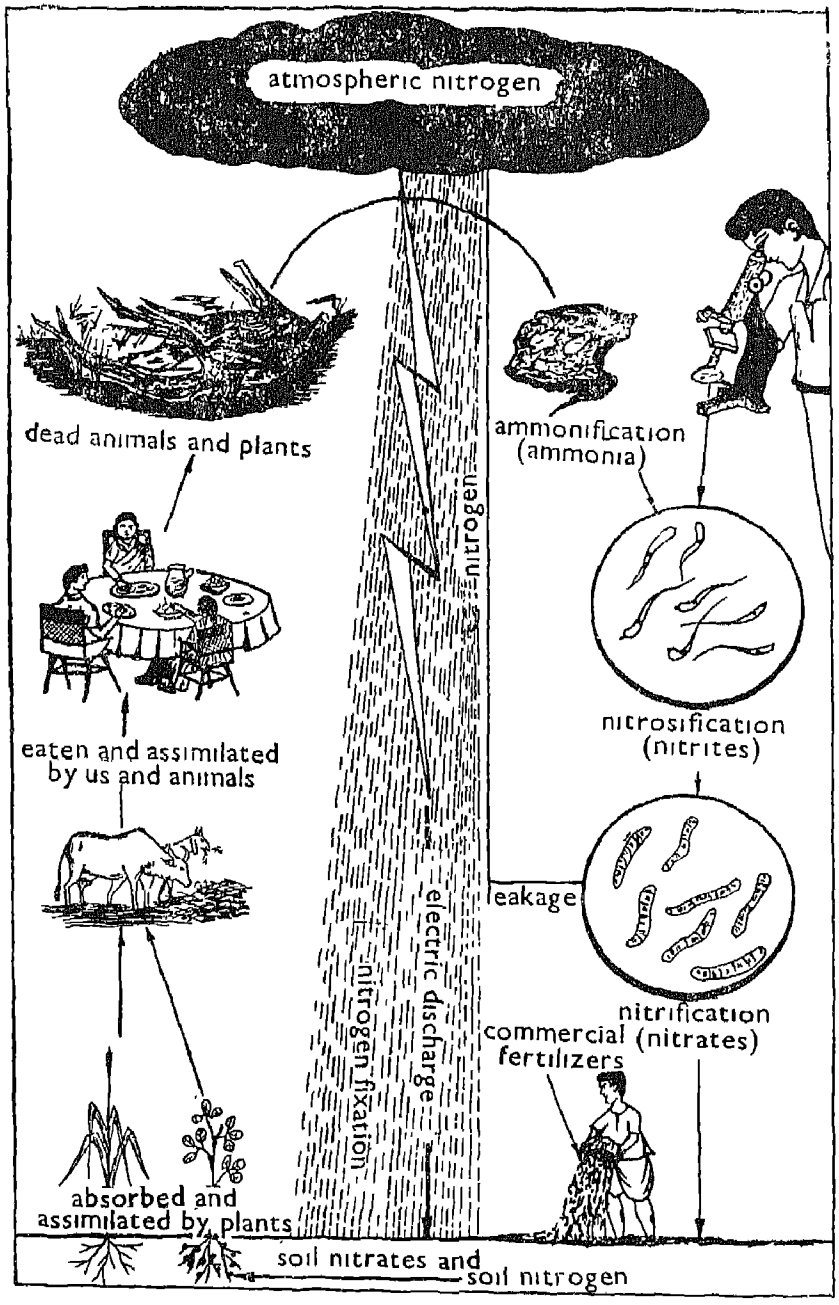

FIGURE 5.3 Nitrogen cycle.

latter convert the ammonia into nitrites. The nitrites are utilized by Nitrobacteria which convert them into nitrates in the soil and this forms the major source of nitrogen supply to the plants.

Some saprophytic bacteria namely, *Azotobacter* and *Clostridium*, which live free in the soil, are capable of fixing atmospheric nitrogen directly. They absorb molecular nitrogen and synthesize amino acids and proteins. These are later released into the environment after their death and decay. There is still another category of these useful organisms which fixes atmospheric nitrogen. They live in the roots of leguminous plants and cause the formation of nodules. The nodule bacteria supply usable nitrogen to the legumes and in return get shelter and carbohydrate supply. The effect of nodule bacteria upon the growth of legumes may be shown as follows :

1. Take some leguminous seeds.
2. Divide them into five equal lots.
3. Smear four lots separately with different strains of *Rhizobium* which may be obtained from any Agricultural Rescarch Institute. The unsmeared lot would serve as a control.
4. Sow the different lots on sterilized soil contained in five sterilized pots.
5. Compare the growth of the seedlings. Also note the extent of nodulation in the different pots. Explain your results. Can you tell now why legumes are rich in proteins ?

In a country where there is acute shortage of food, the importance of leguminous crops in increasing soil fertility assumes great significance. Manuring the soil with farmyard manures, or green manuring or with the addition of chemical fertilizers rich in nitrogen are other devices which should be employed by farmers to enrich the soil.

C. Nitrogen cycle

You have now learnt that nitrogen in the usable form is absorbed from the soil by plants which in turn are largely consumed by animals as food. Some of this nitrogen is returned to the soil in animal excreta and in dead animal and plant tissues that are converted back into usable

soil nitrogen by nitrifying bacteria. Some of the nitrogen of the atmosphere is fixed by the root nodule bacteria of leguminous plants. Atmospheric nitrogen is also fixed by natural physical forces like lightning and washed back into the soil by rain. Some nitrogen is also obtained through the disintegration of mineral rocks. The entire nitrogen cycle is graphically represented in Figure 5.3.

Phosphorus Cycle

A. Importance of Phosphorus

Phosphorus plays a key role in metabolism. It is needed in the synthesis of proteins. It also plays an important part in the formation of energy carrying compound ATP (adenosine triphosphate). Glucose and other compounds combine chemically with a phosphate group at the cell surface to become phosphorylated before they are absorbed by the cell and used as a source of energy. Phosphorus is also an important component of bones and teeth. Soil that is poor in phosphorus retards the growth and maturity of plants. In certain cases phosphorus deficiency causes purpling of leaves and stems.

B. Source

Mineral phosphates, phosphate rock deposits, basic slag (a by-product of the steel industry) and bones are the principal sources of phosphorus. Phosphorus is used in the form of phosphates. As a result of natural breakdown of rocks known as weathering, phosphate ions are released.

C. Phosphorus cycle (Fig. 5.4).

Through the gradual disintegration of phosphate rock deposits by physical forces such as wind, rain, and also through the addition of phosphates as fertilizers by man, the phosphate material accumulates and dissolves in the soil water. A part of the dissolved phosphates is absorbed by the plants through the roots and is used in metabolism whereas a considerable amount is carried continually to the sea by water. The phosphate material in the sea water is used by the marine

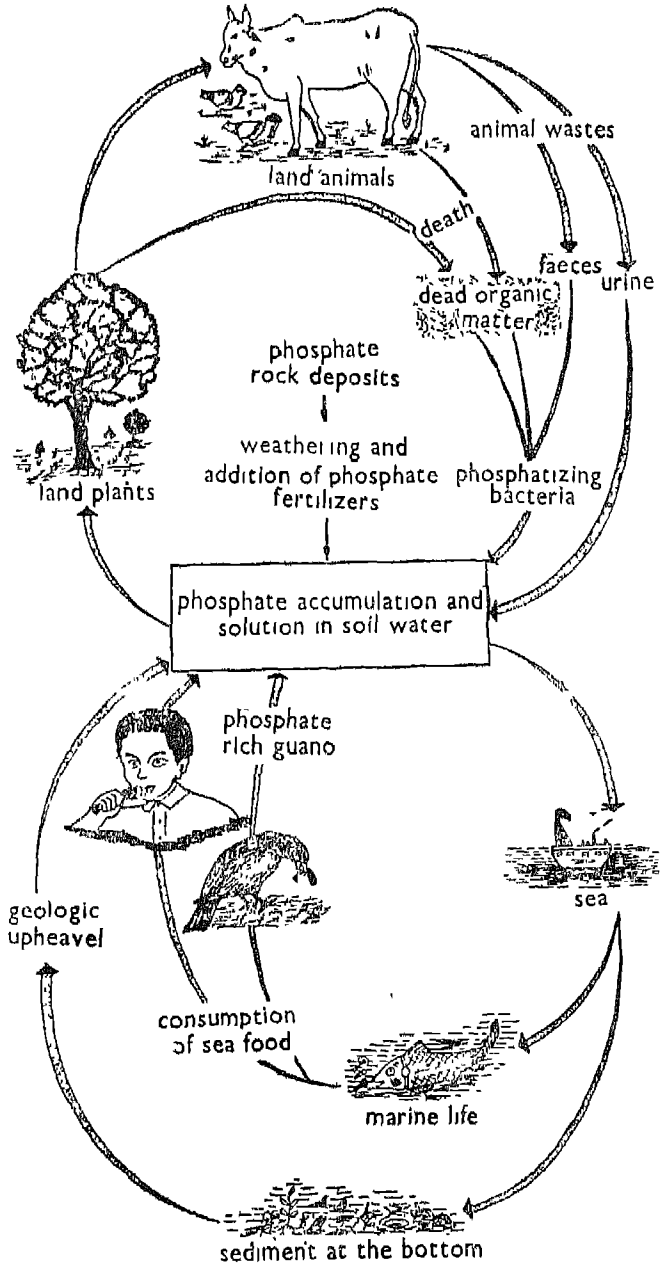

FIGURE 5.4 Phosphorus cycle.

life. In fact it is one of the major nutrients for marine plants. Animals obtain organic phosphates by eating plants as food and inorganic phosphates from the water they drink. Phosphates incorporated into the organic structure of plants and animals are lost to the cycle until their death. Subsequent decay of dead plants and animals by certain bacteria returns the phosphates contained in them to the environment. This completes one possible phosphate cycle which is dependent on microbial activity. Another fraction is recovered from the sea in consuming sea food. Marine birds return yet another fraction of the mineral to the land environment by depositing phosphate-rich guano on the coast. Occasional volcanic eruptions may also add small quantities of phosphates to the environment. A considerable amount of phosphate material, however, is lost to the cycle. It is deposited in the sediments at the bottom of the sea. There it remains out of the cycle until some geological upheaval takes place and brings it up again.

Conclusion

In the preceding pages four natural cycles have been discussed. In each of these occur physical or chemical changes or both in which plants, animals and the environment play a significant role. The environment is the source which supplies the inorganic nutrients (carbon, hydrogen, oxygen, nitrogen and the rest) to the living organisms. These nutrients are used as raw materials in the life processes and are made a part of the living matter. The components of the living matter are finally restored to the source in the following two ways :

1. During the lifetime of organisms as excretory or other by-products.
2. After death, as inorganic materials formed as a result of decay of their dead bodies by saprophytic bacteria and fungi.

For an easier understanding each of the above mentioned cycles has been described as an isolated phenomenon but as a matter of fact all cycles are interdependent and operate continually and concurrently. For instance, the three elements carbon, hydrogen and oxygen are simultaneously involved in the oxygen cycle during respiration. Oxygen combines with carbon and hydrogen to produce carbon dioxide and

water. The carbon dioxide goes back into air to be used again in the carbon cycle and the water to the earth to play its role in the water cycle.

From the account given above it will be clear that oxygen, carbon and hydrogen cycles are closely interlinked and are often combined into a single huge cycle known as the carbon-hydrogen-oxygen cycle.

Energy plays an important role in all these cycles. It is required to produce chemical and physical changes involved in each of these cycles. The energy is either used or liberated. You will recall that the solar energy is used up in photosynthesis. During the process it is stored in the food molecules. This stored energy is released in respiration. A part of it is dissipated into the environment as heat. Most of it, however, is trapped in the ATP molecules in the organism and subsequently used in various ways.

CHAPTER VI

CONSERVATION OF NATURE AND NATURAL RESOURCES

Types of Natural Resources

Man is a child of Nature. All the physical features of the globe, the oceans, rivers and lakes, the hills, dales and forests, the vast sky and clouds and the heavenly bodies together constitute the world of Nature.

Nature in all its entirety profoundly influences, directly or indirectly, the life of man. A few articles that man uses in his daily life are shown in Figure 6.1. Many more things which we use are obtained from nature, in some form or other. The products of nature used by man for his survival or for sustenance and development of human civilization and culture, are termed *natural resources*. So, preservation of nature's resources is of immense value to the human race.

Such resources include *non-renewable* types like minerals, oil and coal and *renewable* types like soil, water, forest vegetation and wild life. Non-renewable resources, once used, are exhausted for ever but renewable resources can be restored. If the non-renewable resources are exhausted at a particular site, a new source or a substitute is to be looked for. For example, we may have to depend completely on solar, thermal and nuclear energy when all the coal beds of the earth get exhausted. It is not possible to find suitable substitutes to replace renewable resources like water, soil, forests and wild life. What we can do is to use them judiciously so that the possibility of their renewal is not hampered.

The entire bulk of these resources may sometimes be upset by natural calamities like flood, drought, etc. But, human acts may also be responsible for some such calamities. If we recall the history of nations, including our own, we find that grave consequences followed

when these resources were not properly used. As the chief consumer of all these resources, man is specially responsible for developing methods and techniques for using the resources of nature "*in such a way that they provide the greatest good, for the greatest number, over the longest period of time*". This is conservation. Our prosperity as well as that of the coming generations depends upon it. Only through a planned and judicious use of these resources and by adopting remedial measures against misuse, can we hope to attain and maintain happiness and prosperity in our country.

At the outset, let us discuss some of the indiscriminate human acts which brought about disaster to the wealth of Nature and made

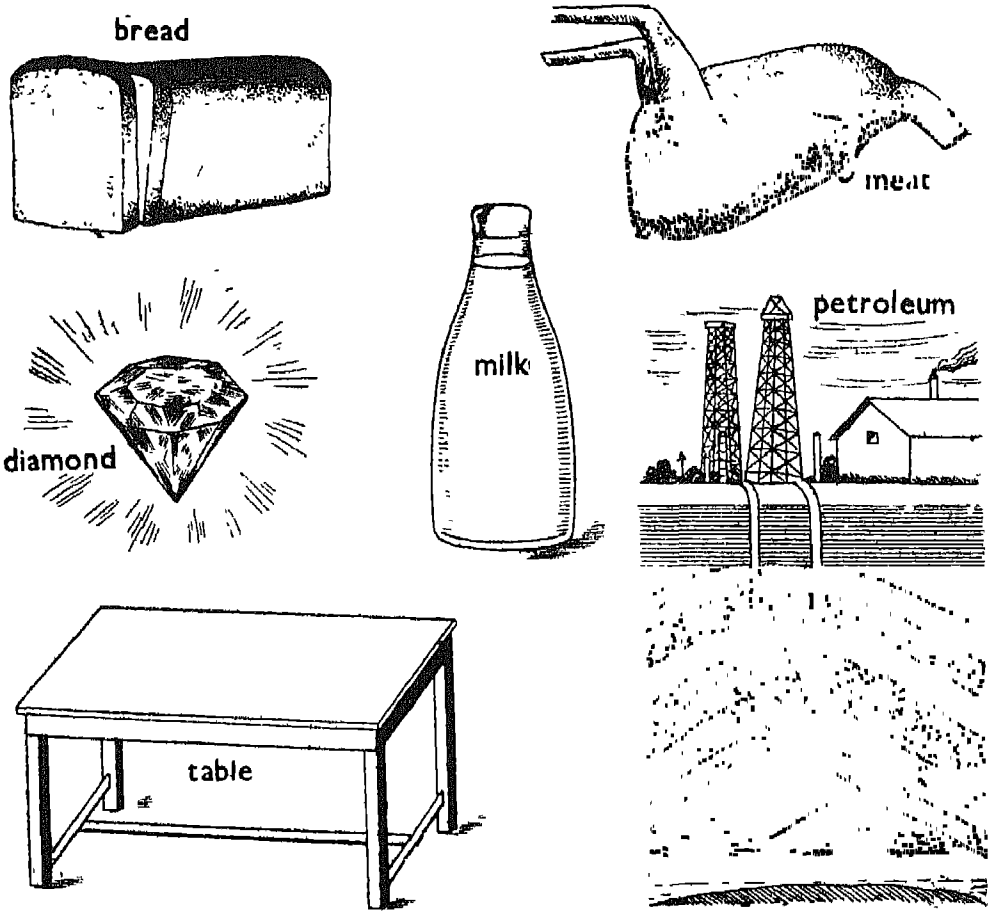

FIGURE 6.1 A few of the many gifts of nature which we use in our daily life.

cautious handling and wise planning obligatory. Here are given two instances in our country, as the evidences of the misuse of natural resources.

Example One

Changed face of the Siwalik

During the middle of the nineteenth century, the Siwalik hills of the Punjab and Himachal Pradesh were covered by trees and other vegetation. It acted as a catchment area of rains and slowly fed the freshwater streams flowing through well-defined banks and carrying freshwater to provide irrigation to the districts of Hoshiarpur and Jullundur. Unchecked destruction of the forests was started later by man together with excessive grazing by cattle. With the removal of the plant cover, the upper layers of the soil were removed and thus the catchment area lost its ability to hold water. Thus, rain water ran off quickly into the river. This sudden influx of water created torrential mountain rivers and caused floods on both the banks. The floods removed the soil cover and gradually the tree-clothed Siwaliks turned into naked rocks leaving little grazing ground for cattle. The streams mentioned above were replaced by seasonal rivulets which often spread coarse sand on otherwise fertile fields.

Example Two

Expanding desert of Rajasthan

The arid belt of Rajasthan is a goat-made desert. Two thousand years ago, the places around Mathura, Brindavan and Agra were covered by large trees like Kadamba (*Anthocephalus cadamba*—a representative tree of the rainy areas). Political instability in these regions lasted for centuries. None cared to prevent the rapid destruction of trees that were used as firewood and fodder. This resulted in a change of climate from humid to arid conditions. The extent of drought has now become so severe that the Rajasthan desert is encroaching about 130 sq. km. of fertile land annually towards Ferozepur, Patiala and Agra (according to a survey of the Central Arid Zone Research Institute of Jodhpur).

It is evident that a balance exists in nature as an interdependent cycle involving soil, water, forests and wild life. As seen in the above examples, direct and indirect interference by man often upset this balance. It affects soil and water first and finally the population of plants and animals. In this chapter, for a better understanding, each resource will be discussed separately.

Soil as a Natural Resource

Soil is a complex mixture of physical, chemical and biological materials. It serves a number of functions in agriculture especially by providing anchorage and sustenance to plants. The composition or quality of a natural soil, undisturbed by man, depends upon five basic factors—*its parental material, climate, internal biological activity, surface contour and time*. Soil is formed by the weathering of rocks. This material may remain above the parental rock (as in the Deccan plateau) or may be removed to other places (as in the Indo-gangetic plain). The broken-down materials are removed by wind and water. If such a movement continues indefinitely, it will serve no useful purpose. In nature, plants bind these loose materials so that the soil becomes stabilized.

The stabilized soil, that has not been inhabited by plants or animals, is called *virgin soil*. Virgin soil may not be fertile. In regions with sufficient rainfall well spread over the year, it becomes fertile provided the soil already contains minerals, organic matters and other energy yielding substances. Man is capable of maintaining the fertility of the soil. Let us examine how the stabilized soil remains arranged in layers :

1. Visit a site where a house is being built or a well is being dug and observe different layers of soil.
2. The exposed layers of the soil (in a cross section) are called *soil profiles* (Fig. 6.2). The different layers are called *soil horizons*.
3. Note that soil is arranged in two distinct layers. The upper layer is called *horizon A or topsoil*, while the lower layer is called *horizon B or subsoil*. The relative thickness of the two layers varies widely.

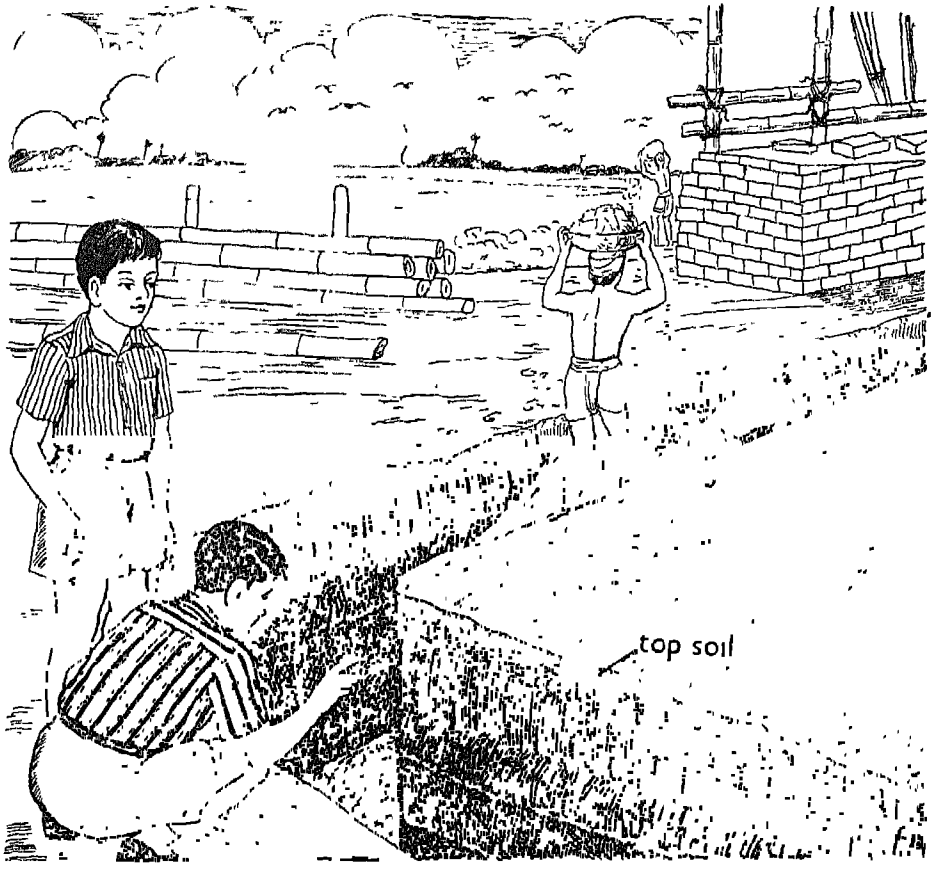

FIGURE 6.2 A site for a new construction. In such places it is distinctly visible that soil is arranged in layers.

In the Indo-gangetic plain the topsoil is thick and more or less red in colour. But in the Deccan plateau, it is right above the parent rock and is black. It contains a high amount of organic materials. The lower layer is deep in the Indo-gangetic plain and shallow in the Deccan plateau. It is almost free from organic matter.

4. Try to dig a part of the ground. You will feel that it is more difficult to dig the deeper layers. It indicates that the sub-soil is more compact.

The top soil is turned over during ploughing. The plants grow well where roots develop well and get their nutrients. When watered,

top soil becomes moist and holds water to a certain extent. In case of excessive rain, water percolates down the sub-soil layers carrying various substances from the top soil in a dissolved state. This phenomenon is called *leaching*. Therefore, any damage to the topsoil will affect plant growth.

Soil erosion

Natural agents like wind and water constantly tend to remove the soil and cause erosion (Fig. 6.3). Human acts may sometimes expedite the process of soil erosion.

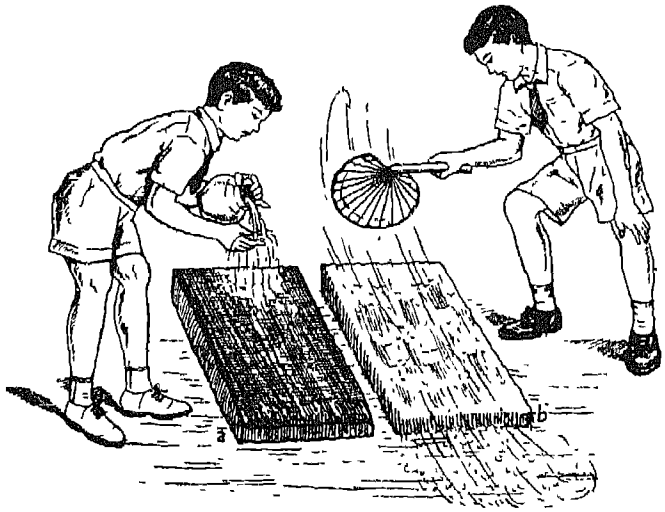

FIGURE 6.3 Picture to show that wind and water cause erosion of soil.

1. Collect a quantity of soil. Make two thick rectangular slabs, each having an area of one square metre and a height of 15-20 centimeters. Make one of the sides higher to form a sloping surface.
2. Make the upper layer of soil of both the slabs loose.
3. Pour water on the top of one slab (a). Fan the other slab (b) producing a strong breeze.
4. Note that in the first slab, water has penetrated into the lower part and has carried down various substances in

a dissolved state. The wind has disturbed the upper layer of the soil in the other slab.

5. Water, therefore, affects the soil to a considerable depth while wind affects its upper part only. Water, besides leaching out nutrients would also carry the soil particles along with it down a sloping surface.

Results of soil erosion

Erosion damages the top soil containing rich organic material, thus making the soil unfit for agriculture, grazing and forestry. Due to the absence of vegetative covering, the eroded soil is unable to hold water which rushes into the river. This rapid influx of water overflows as flood (Fig. 6.4). The dust storm (aandhi) which is common in our country, also causes soil erosion. Such storms blow away the top soil as dust.

Human role in soil erosion

Besides wind and water, man also unwittingly abets in soil erosion. Plants, specially grasses firmly hold the top soil (Fig. 6.5). The growing human habitations, expansion of urban areas and rapid industrialization have led to the complete removal of vegetation from an extensive area of the earth. Once the vegetation is removed, the naked soil remains absolutely at the mercy of wind and water. Improper tillage is another cause of soil erosion. For eradicating weeds and preparing seed beds, farmers often loosen and pulverise the top soil which is carried away by wind and rain. Erosion of soil may also occur if the agricultural fields are left fallow for a long time, particularly in hot dry places.

Remedies of erosion

Some of the steps taken to prevent soil erosion are :

1. Extension of irrigation facilities with a provision of adequate drainage. Intensive cropping can also help mitigate soil erosion.
2. On sloping fields, water flows swiftly causing rapid erosion of the top soil. In such places, in order to reduce the

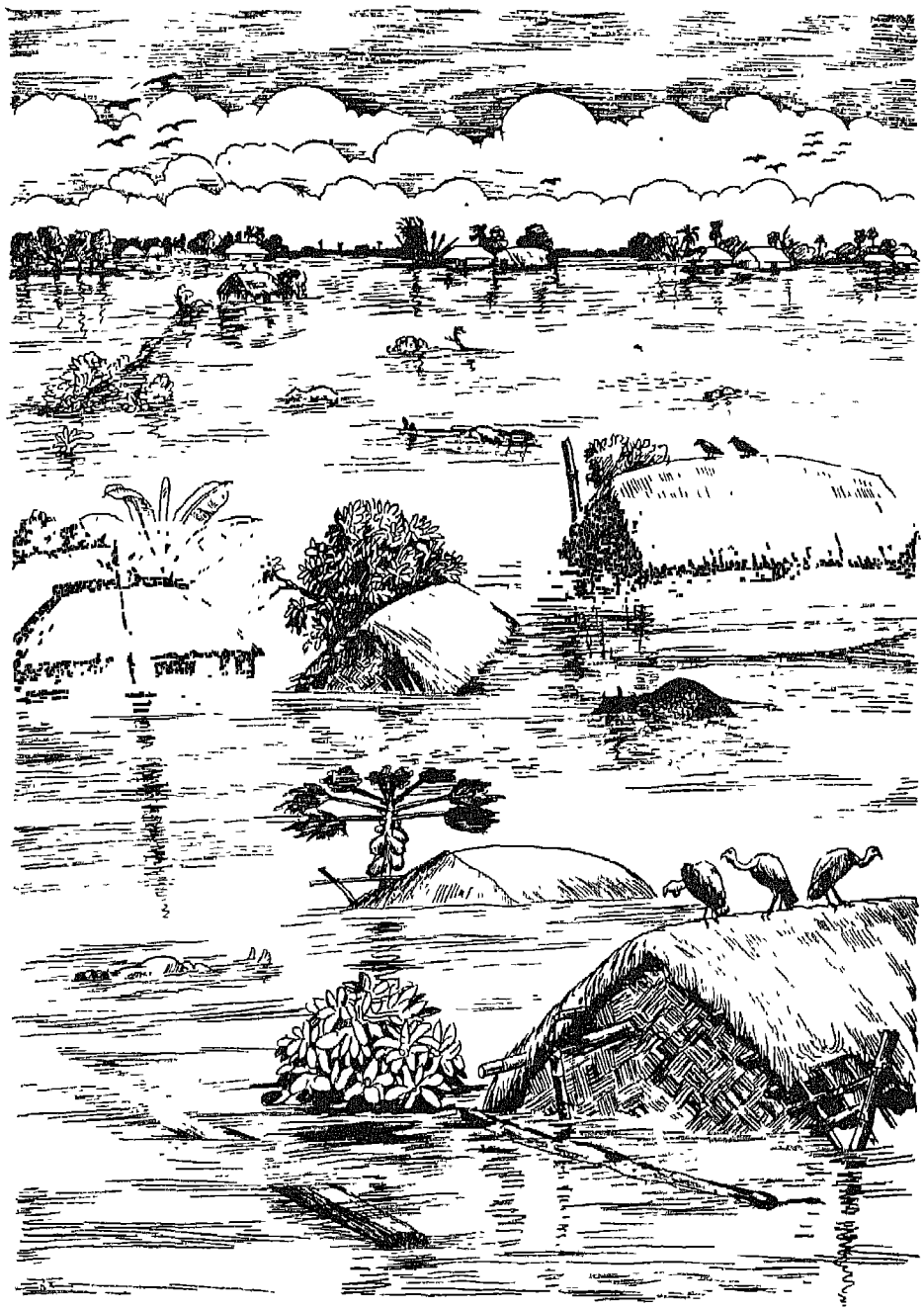

FIGURE 6.4 Ravages of flood, a result of soil erosion.

FIGURE 6 5 Sectional view of soil to illustrate the network of roots which holds the soil.

flow of rain water, the contour of the field is corrected by judicious ploughing. Terracing of the field retards the speed of flowing water.

3. A new system of crop-planting has been adopted in certain regions of the Deccan plateau, where erosion is frequent. In this process, rows of erosion-resisting crops are grown alternately with those of the other plants. Plants like mung (*Phaseolus radiatus*), sem (*Dolichos bifloras*), groundnut (*Arachis hypogaea*) are excellent for preventing soil erosion.

4. The best remedy for erosion is afforestation, i.e., systematic planting of trees. Effective results have been obtained at Digha Beach, West Bengal which is under constant threat of wave action. Similarly, erosion is prevented in some regions of Rajasthan which face storms and high winds. The annual "Vana Mahotsav" (Tree planting

campaign) symbolizes the government sponsored activity to encourage people to plant more trees.

FIGURE 6.6 Figure shows that a covering of grass prevents soil erosion.

(1) Prepare two boxes ready with soil in the way shown in Fig. 6.6.
(2) Cover one with grass sod and leave the other bare.
(3) Pour equal amounts of water on both surfaces.
(4) Measure the drained off water everyday and also examine its colour.
(5) Do you find that from the box containing grass, less amount of water is drained off ? The water is less turbid and carries much less quantity of soil than that from the bare one. The experiment proves that water holding capacity of the grass covered soil is more than the bare soil.

It is to be remembered that unchecked soil erosion can be a menace to all forms of life. Mere government legislation is not enough. It is the duty of all conscientious people to realize the dangers and to implement suitable remedial measures in time.

Water as a Natural Source

To us, water is life. Our body contains a large amount of water and we need water for cooking, bathing, cleaning and agriculture. The importance of water as a natural resource has been realized for a fairly

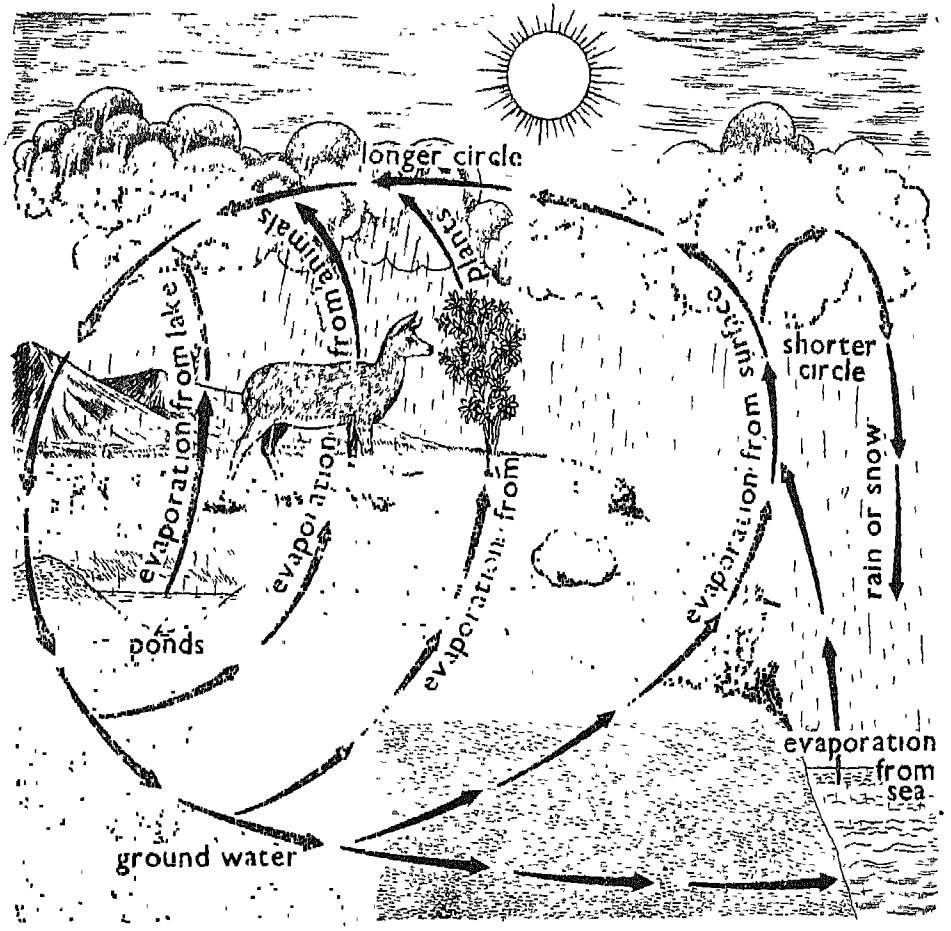

FIGURE 6.7 Cycle of water.

long time. In fact, it is the best solvent known to science. Several ancient human civilizations grew up along some rivers or other water sources.

Examine Fig. 6.7 showing the water cycle. Note that the water we use comes to us as rain, hail, sleet or snow. Water evaporates from the oceans, ponds, lakes, rivers, ground and leaf surface as moisture and forms clouds. Clouds condense into rain drops. The rain water from the surface of soil accumulates partly in lakes or flows down the river and partly percolates through the soil layers. The sources of water we use can be grouped into *surface water* and *underground water*. The surface water includes rivers, lakes and oceans. The underground water represents the water hidden under the layers of soil. After passing through the porous layers of the soil, this water remains above the lower impervious layers. These water reserves rise and form the *water table*. However, the depth of water table below the soil surface is not uniform. In some places, it is closer to the ground level while in other parts it remains at a deeper level. The underground water together with surface water form important natural resources to mankind.

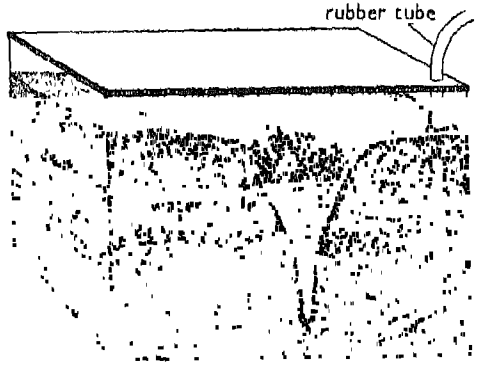

FIGURE 6.8 Figure shows the formation of water table.

1. Take a glass jar and fill it with sand, gravel and soil in the way shown in the Fig. 6.8. The bottom of the jar represents the impervious rocky layer of the soil.
2. Insert a tube in the way shown in the figure and add water slowly.

3. Note how the water is rising up and forms a water table below the dry upper layer.
4. Dig a hole to reach the water table. This is how a well is dug.

Exploitation of water resources

Use of underground water

Because of rapid industrialization and increasing population pressure, man is using up more underground water than what is going down. It has already been pointed out that the vegetation of the soil surface retains more water, thus preventing the rapid run-off of the surface water. It also protects the soil from hail storms and large rain-drops and prevents the evaporation of underground water. Once the vegetation is removed, erosion of the soil takes place causing rapid run off and less percolation of water. So the level of the water table goes down. Besides, forests help in the condensation of clouds to produce rain. The swampy areas (where the water is close to the surface) act as a sponge to hold more water and thus provide the rivers with constant supply of water without silt. It, thus, maintains a steady flow and helps to keep the river mouth clean.

So, the *removal of vegetation* and *clearing of swampy areas* are the two factors which, together with excessive use of underground water, result in the loss of the latter.

Use of surface water

Rivers, the most important surface water source, provide us with water for drinking and irrigation as well as serving as the main arteries for navigation. Rivers lose water during drought and become still and turbid. Due to lack of flow, silts are deposited in its bed resulting in blockage. In such rivers, salinity is increased due to two reasons—(1) restriction in the inflow of water and (2) increased concentration of dissolved salts. Such an increased salinity retards growth of fish populations of the river reducing it unfit for human use. Turbidity prevents the entry of enough sunlight and thus affects the growth of aquatic vegetation.

Besides rivers, lakes and ponds are also important sources of water.

Problem of surface water

The surface water resources are mainly affected by dumping of wastes which, while decaying, remove much of the soluble oxygen from the water. This, on one hand, ruins the fish population and, on the other, promotes the growth of blue-green algae and creates a disagreeable odour. The pollution of water is largely due to both domestic and industrial wastes. It has been reported recently that wastes from a refinery near Monghyr (Bihar) polluted the water of the Ganges to such an extent that it resulted in a heavy loss of human and fish life. In many villages, especially those of West Bengal, Orissa and Bihar the tanks, pools and rivers are used for retting jute plants in order to obtain jute fibres. This makes the water foul and unfit for human consumption. In addition, this water serves as an excellent breeding ground for mosquitoes which propagate diseases like malaria, filaria, etc.

Fight against the loss of water resources

Man has realized the importance of water for a long time but only recently he has understood the importance of finding out means to prevent the loss of water resources. The problem of water conservation is to impound as much of the water as possible in the region where it falls, especially in the hills which serve as *catchment areas*. This is possible by encouraging and aiding vegetation to thrive on the hill slopes. Such afforestation binds the soil and permits more percolation of water than the surface run off. Numerous dams have been constructed near catchment areas to retain water. Otherwise, this water, during the rainy season would lash exposed soils and create an onrush of turbid water in the rivers. The dams not only regulate the supply of water to the fields at the time of need but also maintain a constant flow of clear water in the river. However, dams alone cannot produce the desired water reserves. Afforestation of catchment areas is essential. It prolongs the functional life of the dam by reducing the silting in the dams. The presence of water throughout the season in the river will prevent the

deposition of silt. Such rivers with active flow of water will remain navigable throughout the year and will not become turbid.

To prevent water pollution, in several cities and factories effective measures have been taken to dispose off the sewage. Some municipalities are now in possession of special sewage plants where the sewage is first putrified and then the water alone is released into the river. The solid putrified portions are used as manures. In many factories, arrangements have now been made to produce various by-products from the wastes which were formerly released into the river.

It is a matter of regret that inspite of these measures, still there are people in our country (who are unfortunately in a majority) who pollute water. Unless further steps are taken, it is definite that we will make our rivers and streams unsuitable and unfit for fish habitation.

Forest and vegetational resources

You must have noted the importance of forests and vegetation in protecting soil and water resources. It has been repeatedly observed in every part of the world that removal of forests disturbs the water cycle (see figure 6.7) and gravely affects soil and water conservation. You are already aware of some features of the forests. Let us discuss briefly some aspects of the role of forests as a natural resource, their exploitation and protection.

Forest as a natural resource

In our country, forests near the foothills of the Himalayas and the forests of Madhya Pradesh produce timbers worth millions of rupees. The forests of Assam and Sikkim contain valuable orchids which earn foreign exchange. The wild birds and mammals in forests are also considered as valuable natural resources. Some products of commercial value like honey and wax are also obtained from the beehives in the forests. Bamboo forests in Mysore are the main source of raw materials for the paper industry. But as has already been said, the most important role of the forest as a natural resource is that it prevents loss of water and checks soil erosion thereby providing a suitable abode for *wild life*. Let us see how this works.

(a) As mentioned earlier, forest vegetation binds the soil and thus prevents erosion of the top soil. This permits more percolation of water than the surface run off. This also reduces water logging. Similar functions are carried out by all forms of vegetation whether forests or grasslands. The best examples are seen on the two sides of railway lines, where creepers and grass patches play an important role in binding the soil.

(b) Forests add to the water vapour content of the atmosphere by giving off water in the process of transpiration. It helps in the condensation of clouds which leads to more rain.

(c) Thick foliage helps to break the large and forceful drops of rain, which would otherwise damage the soil.

(d) Forests act as windbreaks without which loose surface soil can get denuded. Forests also prevent crops from lodging in adjoining flat areas due to strong winds.

Exploitation of forests

Excessive consumption of timber and rapid urbanization have led to the destruction of forests. The result of such indiscriminate acts is now actually felt in Rajasthan and its adjoining areas and also more recently in regions around Durgapur of West Bengal. The obvious effects are frequent droughts, floods and dust storms.

Need for protecting forests

Trees which are removed and used as firewood or timber should be replaced by planting new trees. Fire and plant diseases are two factors which damage forests extensively. Therefore, proper care should be taken to protect valuable timber against these factors. In recent years, National parks and conservation forests have been established to afford special protection to forests. These places, over and above their utility as a natural resource, serve as spots for amusement, pleasure and recreation.

Wild Life as a Natural Resource

The loss of soil and water affects man and other animal populations. Man depends much upon both domesticated and wild groups of animals for food, various other products and also for sport.

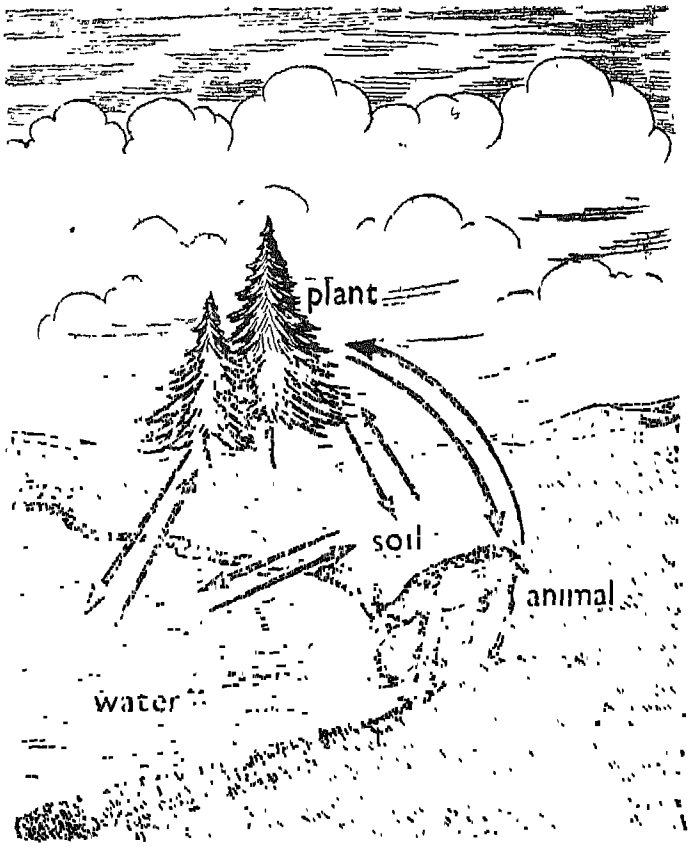

FIGURE 6.9 Figure to illustrate that a balance exists in nature.

You are already aware of the interdependence between plants and animals. Figure 6.9 illustrates the cycle that exists in nature. Any disturbance at any point of this cycle would affect the ecological balance. It is now known that most of the disturbances have been initiated by man who himself started his life as a wild animal. When he removes vegetation, he deprives the herbivorous animals of food and

shelter. They either die or move to some new environments. Such reduction of herbivores in turn affects the population of carnivores. Man's indiscriminate killing of carnivores has led to a prolific increase of herbivores which in turn destroy vegetation. The exposed areas, being at the mercy of rain and wind erode out quickly. Let us examine the wild life resources of India and review how far it has been threatened and how much has been done to protect them.

Animal wealth of India

Our country is well known for the richness and variety of its wild life (Fig. 6.10). They inhabit the regions extending from the wettest areas of the world in north east to the deserts of north west and from the snow clad Himalayas in the north to the humid southernmost tip of Kanyakumari. The wild animals are not only a part of our natural surroundings but also are important for their economic value.

Problem of wild life in India

Rapid influx of population and industrialization are pressing hard on the wild life population. New townships and factories are clearing up forests and jungles, thereby driving the wild life out. But most serious of all is the cruel and indiscriminate killing by poachers and hunters. It has been estimated that the chief reason for reduction in the number of tigers, lions and rhinos is due to such inhuman acts. A direct victim of this is the extinct Indian cheetah, which flourished during the regime of Akbar the Great. The Indian antelope (black buck), upon which it used to prey, has been killed ruthlessly resulting in a dramatic decrease in their number.

During the British rule, the Indian princes for their love of hunting, gave some protection to the game animals. Hunting was a royal game in which commoners usually did not participate. But after independence, when the princely states were merged with the Indian Union, wild life was left uncared for. With the use of sophisticated hunting equipment and the adoption of hunting as a common sport, the wild life of India is in danger of extinction today.

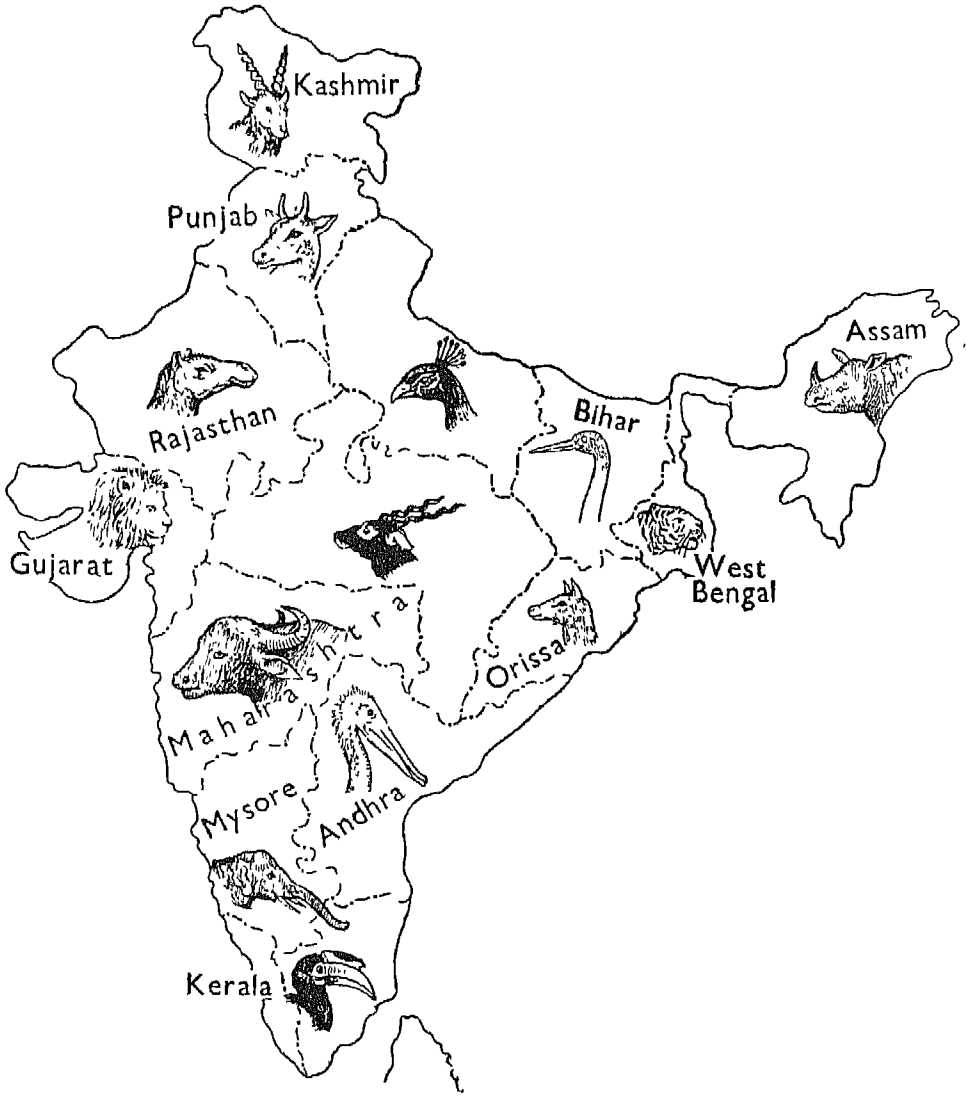

FIGURE 6.10 Richness and variety of wild life resources in our country.

Conservation of wild life

The realization that wild life is a national treasure and that it should be protected, is an old Indian concept. Kautilya's " Arthasastra " (300 B.C.) lays it down that wild animals should be protected in certain

forests called " Abhayaranya " where hunting, capturing or disturbance of animals were to be prohibited by law. The Asoka pillar of 242 B.C. bears inscriptions encouraging the protection of wild animals. In many parts of the country, it is customary to prevent the killing of animals during their breeding or migratory season. In places like Vedanthangal (South India) the local people and the government protect the seasonal bird migrants from hunters. The people of Rajasthan villages protect the wild animals of their locality.

In recent times, the well known hunter, Jim Corbett (the author of the famous book " Man-eaters of Kumaon "), in association with a society organized in the Uttar Pradesh, pioneered wild life preservation in the area. This laudable trend has been pursued by the states of Punjab and Himachal Pradesh. But, whole-hearted efforts in this direction were made only in 1952 when the " Indian Board for Wild Life " was established. Though the states directly control the conservation of wild life, the Board formulates and recommends various steps for its protection and well-being. Thirteen animals, the *lion*, the *snow leopard*, the *clouded leopard*, the *cheetah*, the *rhinoceros*, the *Indian wild ass*, the *Kashmir stag*, the *musk deer*, the *brow-antler deer*, the *pygmy hog*, as well as birds like the *great Indian bustard*, the *pink headed duck* and the *white winged wood duck* are considered rare and are offered full protection (Fig. 6.11). A number of sanctuaries and parks have been established in the country where indigenous fauna can flourish without risk. In these sanctuaries, hunting, shooting and trapping of all animals and birds are prohibited. Periodic census has been taken to study the numerical status of the population. From 1952 to date, these efforts have shown encouraging results and rapid decline of many animals has been effectively checked.

You and conservation of wild life

The forests and wild life are the country's heritage and it is our duty to preserve them. Law alone is not enough for their conservation. This can be achieved if you, the citizens of modern India, are sympathetic to them and become more conscious of your duties towards their protection. Magnificent animals like the elephant, tiger, lion and rhino of our country make us proud. How pleasant and charming are the beautiful birds

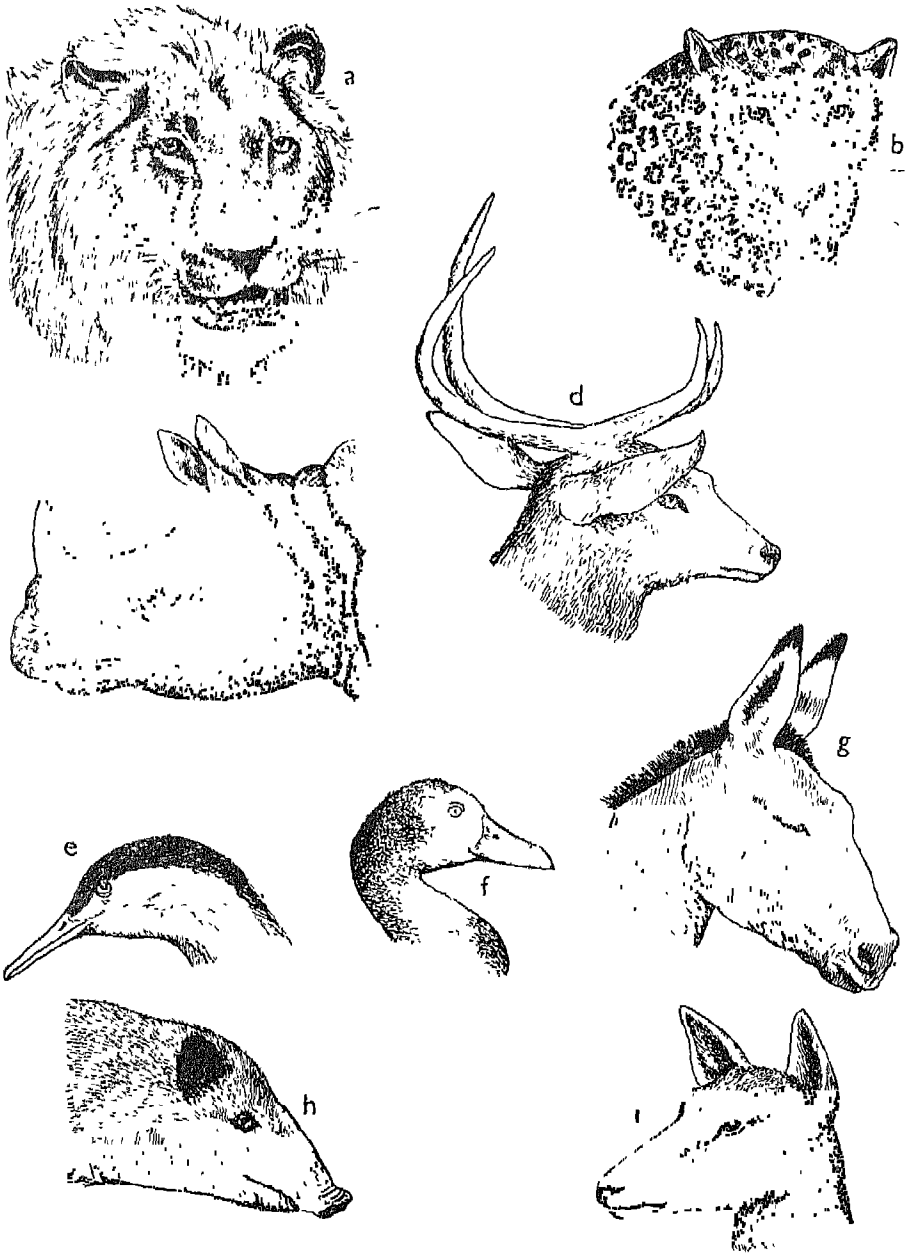

FIGURE 6.11 A few of the thirteen species of animals of our country which are afforded full protection.

and their melodious tunes. It is our duty to see that there is no attempt to destroy our precious wild life. The wild animals, such as the deer are, sometimes, as much an enemy as the tiger or lion because the former often graze and destroy agricultural crops. But any step to control the movement of such wild animals should be taken by competent persons belonging to the wild life service.

Wild life should be conserved also for their important role in maintaining the balance of nature. It has been recorded that indiscriminate interference (either by introduction of new animals or by destruction of the existing animal population) seriously affects the ecological balance.

Lastly, it should be borne in mind that if we are not alert enough, we may see our forests, in the not too distant future, lose magnificent animals like lions, elephants and rhinos. If it happens in reality, we shall remain morally responsible to posterity for their extinction.

GLOSSARY

Aestivation—Dormancy during summer or dry season

Ammonification—The release of ammonia due to the decomposition of organic nitrogen compounds.

Biomass—Is the number and total weight of organisms at each level in the ecosystem which is determined by the flow of energy in ecosystems from sunlight.

Buttress—Additional support to a tree trunk produced from its base.

Cold-blooded animal—An animal whose body temperature is related to the environment in which it lives.

Community—All the plants and animals of an area.

Conservation—The act of preservation and maintenance of natural resources like animals, plants, soil, water, minerals, etc., over the longest period of time for the benefit of mankind.

Consumer—Heterotrophic organisms, chiefly animals that ingest other organisms or particulate organic matter.

Decomposer—Heterotrophic organisms, chiefly bacteria and fungi that break down the complex compounds of dead protoplasm, absorb some of the decomposition products, and release simple substances usable by the producers.

Dentrification—The reverse of nitrification.

Ecosystem—A community of organisms interacting with one another, plus the environment in which they live and with which they also interact, *eg.*, a pond, a forest.

Epiphyte—Plant growing on another plant, not growing parasitically upon it but merely using it for support.

Erosion—Removal of soil and lowering of surface of land by the action of wind, running water and also by human agents.

Food chains—Animals linked together by food and all dependent basically upon plants. A series of species in an association each of which lives (in part at least) as a predator or parasite on the next in the series.

Food cycle—A fairly complete analysis of the food relations between the species in an association showing where each species obtains its food and what other organisms in turn derive food from it.

Food pyramid—A food chain can be visualized as a pyramid where each step in the pyramid is much smaller than the one on which it feeds.

Gravid female—Female with eggs.

Hypanthodium—An inflorescence with a concave receptacle on whose walls the flowers are arranged.

Leaching—Percolation of water with the removal of dissolved chemicals from the soil surface.

Legume—A pod; a fruit formed from a single carpel, splitting along the dorsal and ventral sutures.

Leguminous plants—Plants producing legumes, *eg.*, pea (see legume).

Lianas—Climbing plants found in tropical forests, with long, woody, rope-like stems of anamalous structure.

Lichens—An association of an alga and a fungus for mutual benefit.

Litter—Dead organic matter that accumulates on the soil surface.

Nitrification—The oxidation of nitrites to nitrates by *Nitrobactor* and certain other bacteria.

Nitrosification—The oxidation of ammonia to nitrites by *Nitrosomonas* and certain other bacteria.

Nocturnal—Active during the hours of darkness rather than by day.

Pollution—The act of fouling or contaminating of water and air with disagreeable materials originating from industrial wastes.

Primary productivity—The total assimilation rate of producers in an ecosystem.

Producer—Autotropic organisms, largely the green plants.

Sanctuary—A protected place where plants, and animals are allowed to thrive without any fear of extermination by man.

Saprophyte—Organism which obtains organic matter in solution from dead and decaying tissue of plants or animals.

Soil—A complex mixture of biological and physical matters derived from the weathering of rocks, forming the outermost surface of the earth, on which vegetation flourishes.

Strangler—A plant that begins its life as an epiphyte and in course of time strangles its host to death.

Sub-soil—Lower layer of soil, generally poor in organic matters, holding water.

Swamp—An area of wet, spongy, low land filled with stagnant water, unsuitable for agriculture.

Synconium—Multiple hollow fruit developed from hypanthodium, *e.g.*, Fig fruit.

Top-soil—The uppermost layer of the soil, rich in organic materials.

Zygote—The cell resulting from the sexual union of two gametes; a fertilized egg.

DEAR READER,

In presenting another set of Biology Text Books IV to VI and Teacher's Guides at an advanced level over Books I—III, already published, we have set to address students of the Indian Secondary and High Schools. The same Biology Study Groups that edited the previous set are now presenting this series for try outs on as wide a scale as possible.

Whilst it is true that the teaching of Biological Sciences in the West has made great strides since 1960, we have not as yet geared ourselves to the task of bringing the materials within the comprehension of the Young Indian Students. The reasons are many and among them two seem most important. The teacher has few authentic texts designed for our Indian conditions and the school laboratories lack some of the basic equipment necessary for meaningful demonstrations which are so vital for understanding biological phenomena. The bringing out of a text, therefore, seemed the most urgent task and once this was made available, thought could be bestowed on developing kits, charts and audiovisual aids that could make the teacher's task simpler and more direct than now. For the first time in our country, a large section of biologists in the Universities have collaborated in this Programme of Science Education in schools and these books are the result of their efforts.

We have genuine pleasure in sending these volumes to you with the definite purpose of eliciting your suggestions for improvement of this experimental edition. We enclose a questionnaire which kindly fill after studying the books and return to us.

Biology Text Books and Teacher's Guides (I—III) are currently under revision taking into account the valuable comments received from many teachers and educationists who very kindly offered their suggestions for improvement. It is expected that these revised books will be in the field when we have had more time to finalize the text matter.

Yours sincerely,

University Botany Laboratory,
Chepauk, Madras-600005.

T. S. SADASIVAN.

COMMENTS ON THE NCERT BIOLOGY STUDENTS' TEXTS IV—VI.

BOOK IV

Name, designation and address of the person making comments

Date *Signature*

ON THE QUESTIONNAIRE

With a view to upgrade the standard of biology education in India and bring it on par with the standard of advanced countries, the present books IV—VI have been written for standards VIII to X (age groups 13+ to 15+). After careful planning the books have been written by competent biologists in the country with the main objective of upgrading the curriculum. Therefore, the aim of these books is to provide a modern version of biology as a whole with a slant on experimental approach to the subject, in order to promote a sense of inquiry in the young pupil's mind. The views of the teachers and educationists on these books are of utmost importance in finalising the texts The following questionnaire has, therefore, been appended. Brief answers may be given against these questions, but where detailed suggestions are to be made, separate forms attached herewith may be used.

1. Do you consider the chapters clearly expressed and understandable to students to whom they are addressed? If not, modifications may be suggested.
2. Do you think that thought development in the chapter is gradual, sequential and continuous? Are there places which are jumpy? If so, your suggestions regarding alterations may be given.
3. Do you think that the approach to the topic is such as would invoke curiosity and promote a sense of inquiry in the mind of the student? Is there any place which needs rewriting to achieve the above result? If so, give your suggestions.
4. (i) Do you think that the practical experiments suggested are adequate?
   (ii) Do you wish to add any experiment, and if so, where?
5. (i) Does any of the practical tests need simplification or modification? (Suggestions may

be given keeping in mind the investigatory approach).

(ii) Will you be able to conduct the experiments successfully in time? State the difficulties you may encounter.

6. Are plant and animal materials required for practicals readily available in your locality? If not, what alternative materials would you suggest? (Would you be willing to exchange materials with other centres, if so, give details.)

7. Are the illustrations accurate and adequate to drive home the point? If not, suggest what more can be included.

8. Any other suggestions you may desire to make, such as organizing biological specimen supply centres on a national basis

(Ideas on new approach, reference material, publications or books, starting of news letters or Resources Bulletins etc. that might be useful may be given).

Form for answering (in detail) the questions in the questionnaire relating to Biology Text Books IV—VI.

Book No. Question No.	*Chapter and Page No.*	*Modifications or other suggestions for improvement.*